File No. S360-00
Form A22-6810-8

Online is Rev 0 & Rev 12
(bracket)

IBM Systems Reference Library

IBM System/360 System Summary

This publication provides basic information about the IBM System/360, with the objective of helping readers to achieve a general understanding of this new data processing system and the interrelationships of its models and parts. Broad system concepts, basic and optional features, and specific input/output devices are briefly discussed.

This publication does not apply to System/360 Model 20. All Model 20 publications are listed in the *IBM System/360 Model 20 Bibliography*, Form A26-3565.

Detailed information on processing is in *IBM System/360 Principles of Operation*, Form A22-6821. Description of programming systems and languages, as well as further details on the I/O devices and teleprocessing capabilities described herein, are in publications listed in the *IBM System/360 Bibliography*, Form A22-6822 and *IBM Teleprocessing Bibliography*, Form A24-3089.

NINTH EDITION

This is a major revision of, and obsoletes, A22-6810-3 through A22-6810-7 and Technical Newsletters N22-0168, N22-0182, N22-0186, N22-0194, N22-0203, and N22-0212. The entire manual has been rewritten to reflect numerous additions and changes.

Significant changes or additions to the specifications contained in this publication will be reported in subsequent revisions or Technical Newsletters.

Requests for copies of IBM publications should be made to your IBM representative or to the IBM branch office serving your locality.

This manual has been prepared by the IBM Systems Development Division, Product Publications, Dept. B98, P. O. Box 390, Poughkeepsie, N. Y. 12602. A form is provided at the back of this publication for readers' comments. If the form has been removed, comments may be sent to the above address.

©International Business Machines Corporation 1964, 1967.

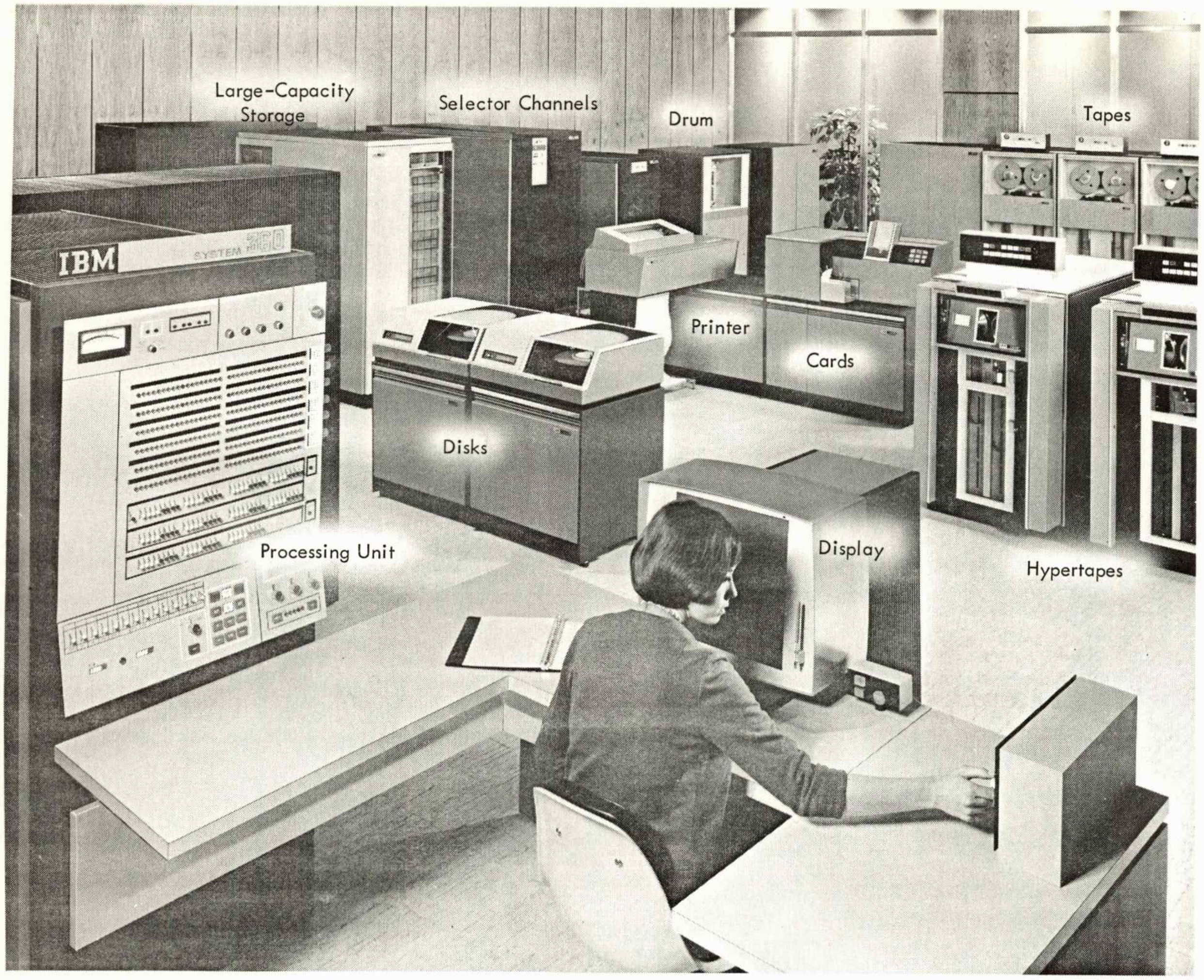
Contents

Introduction to the System Concepts 5
System Concepts 6
  Unified Design 6
  Universality 6
  Processor Storage 6
  Protection of Storage 7
  Large-Capacity Storage (LCS) 7
  Shared Main Storage 8
  Arithmetic 8
  Instructions 9
  Compatibility Among System/360 Models 9
  Open-Ended Design 10
  Interruption System 10
  System Accuracy and Reliability 11
  Universal Code Capability 11
  Channels 11
  Communication Among CPU's 13
  Time Sharing 14
  Flexibility in Speed, Storage, Features, and I/O 15
  Standard Connections for I/O Devices 15
  Direct Control and External Interruption 15
  Ascertainment of Times and Intervals 16
  System Controls 16
  Compatibility with Other IBM Systems 16
Programming Systems 17
  Basic Programming Support (BPS) 17
  Special Systems Support 17
  Operating Systems—General Facts 17
  Specific Operating Systems 18

System Methods 20
Machine Addressing 20
Formats 20
Interruption and Program Status Word 20
Particulars on Multiplexer Channels 22
Control of I/O 22

Input/Output Devices 24
VISUAL INPUT/OUTPUT 25
  IBM 2250 Display Unit Models 1 and 3; IBM 2840 Display Control Model 2 25
  IBM 2814 Switching Unit Models 1-3 29
  IBM 2260 Display Station; IBM 2848 Display Control Models 1-3 29
MANUAL CONTROLS 32
  IBM 1052 Printer-Keyboard Models 3, 5, 6, 7, and 8 32
  IBM 1051 Control Unit Models 1 and N1 33
  IBM 2150 Console 33
TAPES 34
  IBM 2401 Magnetic Tape Unit Models 1-6; IBM 2803 Tape Control Models 1 and 2; IBM 2804 Tape Control Models 1 and 2 34
  IBM 2415 Magnetic Tape Unit and Control Models 1-6 37
  IBM 7340 Hypertape Drive Model 3; IBM 2802 Hypertape Control 37
  IBM 2816 Switching Unit Models 1 and 2 39
  IBM 2671 Paper Tape Reader; IBM 2822 Paper Tape Reader Control 39
DIRECT ACCESS 41
  IBM 2302 Disk Storage Models 3 and 4 41
  IBM 2303 Drum Storage 41
  IBM 2311 Disk Storage Drive 42
  IBM 2321 Data Cell Drive 42
  IBM 2841 Storage Control 43
  IBM 2301 Drum Storage; IBM 2820 Storage Control 44
  IBM 2314 Direct Access Storage Facility; IBM 2844 Auxiliary Storage Control 44
  Single-Disk Storage Drive 45
CARD INPUT/OUTPUT 47
  IBM 1442 Card Read Punch Model N1 47
  IBM 1442 Card Punch Model N2 47
  IBM 2501 Card Reader Models B1 and B2 47
  IBM 2520 Card Read Punch Model B1 48
  IBM 2520 Card Punch Models B2 and B3 48
  IBM 2540 Card Read Punch 49
PRINTERS 50
  IBM 1053 Printer Models 1 and 4 50
  IBM 1403 Printer Models 2, 3, 7, and N1 50
  IBM 1404 Printer Model 2 51
  IBM 2821 Control Unit Models 1-5 52
  IBM 1443 Printer Model N1 53
  IBM 1445 Printer Model N1 53
MAGNETIC INK 54
  IBM 1412 Magnetic Character Reader; IBM 1419 Magnetic Character Reader 54
OPTICAL 56
  IBM 1231 Optical Mark Page Reader Model N1 56
  IBM 1285 Optical Reader 56
  IBM 1287 Optical Reader Models 1 and 2 58
  IBM 1418 Optical Character Reader Models 1-3; IBM 1428 Alphameric Optical Reader Models 1-3 60
I/O Equipment Pertaining to USASCII 61
Attachment of Devices 61

Teleprocessing, Data Acquisition, and Process Control 65
  Requirements of a Teleprocessing System 65
  Transmission—Directions, Grades, and Modes 65
  Terminal Connections to Communications Lines 67
  Data Sets 67
TELEPROCESSING SYSTEMS AND DEVICES 68
Transmission Control 68
  IBM 2701 Data Adapter Unit 68
  IBM 2702 Transmission Control 70
  IBM 2703 Transmission Control 71
  IBM 2712 Remote Multiplexer 72
Terminals 73
  IBM 1001 Data Transmission Terminal 73
  IBM 1092 and 1093 Programmed Keyboards 73
  IBM 2740 Communications Terminal 74
  IBM 2741 Communications Terminal 75
Systems 76
  IBM 1030 Data Collection System 76
  IBM 1050 Data Communication System 76
  IBM 1060 Data Communication System 78
Line Adapter Units 79
  IBM 2711 Line Adapter Unit 79
Audio Communications 79
  IBM 7770 Audio Response Unit Model 3 79
  IBM 7772 Audio Response Unit 80
DATA ACQUISITION AND PROCESS CONTROL 82
  IBM 1070 Process Communication System 82
  IBM 1800 Data Acquisition and Control System 83



For Model 30, see Figure 3.
For Model 40, see Figure 4.
For Model 50, see Figure 5.
For Model 75, see Figure 6.
For Model 75 processing unit, see Figure 9.

IBM System/360 Model 65

IBM System/360 is an entirely new data processing system, brought into existence to provide the comprehensive range of computing versatility required by the many modern challenges of industry and science. The models within this system are identical in concept and compatible in programming but are matched in size, speed, and cost to the various new applications and data rate demands.

The design effort for the System/360 addressed major needs that, historically, have faced the computer customer: large high-speed storage capacities; improved facilities for communications; fixed and variable-length field capabilities; and the ability to efficiently process both commercial and scientific information.

Embedded in the basic design philosophy was the principle that the measurement of the system would not be solely in events per microsecond, but, more importantly, in answers per dollar per month.

All these objectives, and many others as significant, are presently realized in the IBM System/360.

An important aid toward the accomplishment of these design objectives was a technological change, a new dimension in data processing—solid logic technology, called SLT and classed as the third generation in components. (See Figure 1.) This is the first time that a commercially available system has been built using micro-miniaturization of components and circuits.

The use of SLT has four direct results: higher speed, more compactness, greater reliability, and lower cost. Of these, speed and compactness are closely interrelated; small parts allow high circuit densities, shortening the distances signals must travel.

The System/360 is not, however, dependent on SLT, but takes continuing advantage of the frontier technologies: ASLT (advanced SLT), SLD (solid logic high density), and even higher performance circuit packaging yet to come.

Data throughput has been radically increased through new principles leading to more internal ma-

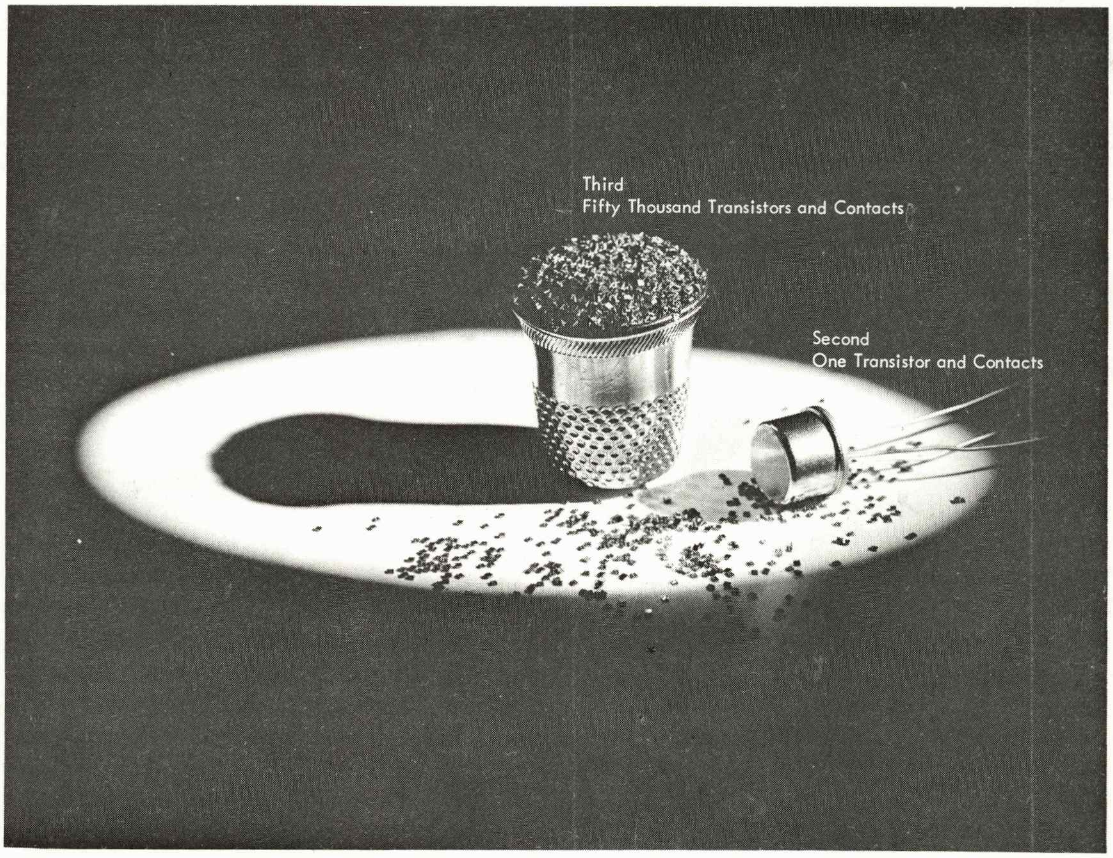

Third
Fifty Thousand Transistors and Contacts
Second
One Transistor and Contacts

Figure 1. Second and Third Generation Components

chine efficiency; for example, logical concepts, such as accumulators, no longer necessarily imply a type of physical structure. The engineering design for logical requirements has broken out of traditional forms and is now strictly based on cost performance.

The System/360 is generally capable of supervising itself, with little or no manual intervention for routine tasks. This is effected by the control programs, by nonstop operation, by delegation of I/O control to channels, by a timer, by the tamperproof storage protection, and by the interruption system to be discussed.

System Concepts

Unified Design

The System/360 approach does much to organize data processing and simplify the tasks of the operator and problem programmer. In the range of models (30, 40, 44, 50, 65, 67, 75, and 91), each higher numbered model has, in general, substantially faster internal performance. The performance points through this range are obtained by:

The speed of the storage;
The speed of the circuits;
The amount of information moved throughout the system at one time, and
The number of events that can take place at one time.

These differences in speed and simultaneity greatly affect over-all performance; with the limited exceptions given under "Compatibility Among System/360 Models," none affects the appearance of the design to the programmer, nor does it affect the results of any program.

Universality

The System/360 is a truly general-purpose system designed to meet the needs of the commercial, scientific, communications, and control system users. It obviates the choice between a "commercial" system with its decimal arithmetic, variable-length fields, editing capabilities, etc., and a "scientific" system with its high storage utilization (because of binary format), high-speed arithmetic, etc. The System/360 combines all such features.

This means that applications formerly assigned to various systems are now being done by a single universal system; this is true whether the application is large or small and regardless of the type—commercial, communications, scientific, control, or mixed.

Universality has a side benefit: once the user's systems personnel have been trained in the operation of one of the System/360 models, they understand all models of the system.

Processor Storage

Capacity of processor storage varies from 8,192 to 6,291,456 bytes, depending on the system model (Figure 2). A byte consists of eight bits plus a parity (check) bit, and is the smallest addressable unit in the IBM System/360. Storage capacities are always given in bytes.

The history of data processing shows that the main barrier to expanding the work that can be done on a computer has been that the amount of core storage that can be addressed by a system rapidly becomes much too small as the jobs grow bigger. The System/360, however, has in its design the logical capability of addressing up to 16,777,216 bytes. For greatest storage addressing efficiency, address arithmetic is done exclusively in binary.

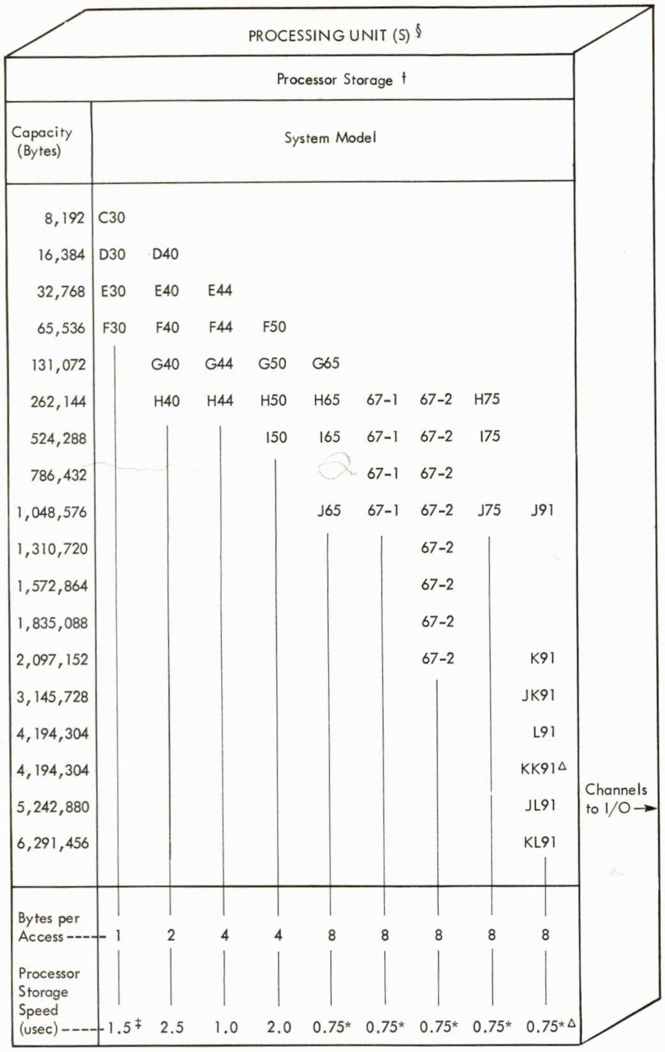
Interleaving

As instruction decoding and executing circuits are made ever faster, an increasing proportion of processing time is devoted to making accesses to storage. In the larger models of System/360, storage speed could have become the limiting factor. The natural way to have attacked this limitation would seem to have been by increasing the storage speed. An indirect way of overcoming it, ranging from a marked improvement in the *effective* speed to the point where storage speed ceases to be a limiting factor, is through the addressing technique called interleaving.

A storage unit reads out or accepts data from the CPU at a fraction of its total cycle, but must then complete its own cycle with internal housekeeping. Because only the first part of this storage cycle is material to the processing, an access can be made to a different storage unit while the first unit is still busy. When this is done, sequential addresses are distributed through two or more units of storage; the first access is to unit 1, the second to unit 2, etc.

Without interleaving, the rate of accessing storage depends almost entirely on the processor storage cycle or speed. In effect, however, interleaving divides the average time per storage cycle by as much as the number of ways in which storage is interleaved.

At the simplest, accesses are alternated between two storage units, and this is called two-way interleaving. In the most powerful models, accesses are alternated among as many as 16 storage areas. The net effect, in all cases, is a dramatic decrease in the average time per sequential access compared with the specific access time; and this results in much faster processing of data.



Capacity (Bytes)	System Model								
8,192	C30								
16,384	D30	D40							
32,768	E30	E40	E44						
65,536	F30	F40	F44	F50					
131,072		G40	G44	G50	G65				
262,144		H40	H44	H50	H65	67-1	67-2	H75	
524,288				I50	I65	67-1	67-2	I75	
786,432						67-1	67-2		
1,048,576					J65	67-1	67-2	J75	J91
1,310,720							67-2		
1,572,864							67-2		
1,835,088							67-2		
2,097,152							67-2		K91
3,145,728									JK91
4,194,304									L91
4,194,304									KK91∆
5,242,880									JL91
6,291,456									KL91
Bytes per Access	1	2	4	4	8	8	8	8	8
Processor Storage Speed (usec)	1.5‡	2.5	1.0	2.0	0.75*	0.75*	0.75*	0.75*	0.75*∆

§ Model 67-2 has as many as four processing units. All other models have one processing unit.

† Processor storage in Models 65-91 is housed externally to the processing unit (CPU).

‡ 2 microseconds if the CPU was obtained under a special purchase contract for Model 30.

* Effective access time is much less than 0.75 microsecond; interleaving of storage alternates sequential accesses between two storage units. Exceptions: no interleaving for G65; 4-way interleaving for I75 and J75; 8-way interleaving for J91; 8-way interleaving in the first 1,048,576 bytes (and 16-way in the rest) for JK91 and JL91; 16-way interleaving for K91, KK91, KL91, and L91.

∆ Models J91 and K91 use high-performance storage only; Model L91 uses extended storage only; Models JK91, JL91, KK91, and KL91 use both. Total storage cycle is the same in both types, but total access time decreases to 0.6 microsecond for high-performance storage and increases to 0.9 microsecond for extended storage. The effective rate of accessing storage is greatly improved through interleaving.

Figure 2. Processor Storage Capacity, Speed, and Bytes Per Access

The degree of interleaving for each model that makes use of this technique is specified in Figure 2.

Protection of Storage

Store Protection

Store protection prevents the contents of storage from being altered by errors in programs or input from I/O devices. As many as 15 different programs, each existing in any number of 2,048-byte storage blocks (which may be non-contiguous), can be protected at any one time. The number of programs and blocks depends on the capacity of main storage. (Main storage is the term for all addressable core storage: that is, processor storage plus any large-capacity storage.)

All input operations are monitored for violations of store protection; the control program is alerted and takes appropriate action when any such error occurs. This protection of storage, vital for applications in communications, causes no loss of performance.

Store protection is available for all models: as a standard feature for Models 50-91, or as a special feature for Models 30-44. On the 44, it is available only together with fetch protection.

Fetch Protection

Fetch protection is a standard feature on Models 65-91 and a special feature for Model 44; it prevents the unauthorized fetching of data and instructions from main storage. When this feature is installed, blocks of storage may be protected against store violations or against store and fetch violations but not against fetch violations alone. The fetch protection feature operates the same way as the store protection feature, and is controlled by the same two instructions: SET STORAGE KEY and INSERT STORAGE KEY.

Large-Capacity Storage (LCS)

The processing power of Models 50, 65, and 75 can be expanded by adding large-capacity storage (see frontispiece) in blocks of either 1,048,576 or 2,097,152 bytes, to a maximum of 8,388,608 bytes. Available capacities are, in round numbers, 1, 2, 4, 6, or 8 million bytes. This storage is addressed contiguously with processor storage. The number of bytes obtained per storage access, and all other features of LCS except its 8-microsecond speed, are the same as those of the processor storage of the system to which it is attached. Its protection features are standard.

An advantage of LCS is that it accommodates, in protected storage, large records or vocabularies heretofore located in auxiliary storage media, thereby reducing the number of time-consuming references to I/O devices. Also, LCS can contain large problems, with extensive reference tables, throughout their execution.

If the two-way interleaving optional feature is specified for LCS, sequential accesses are alternated between

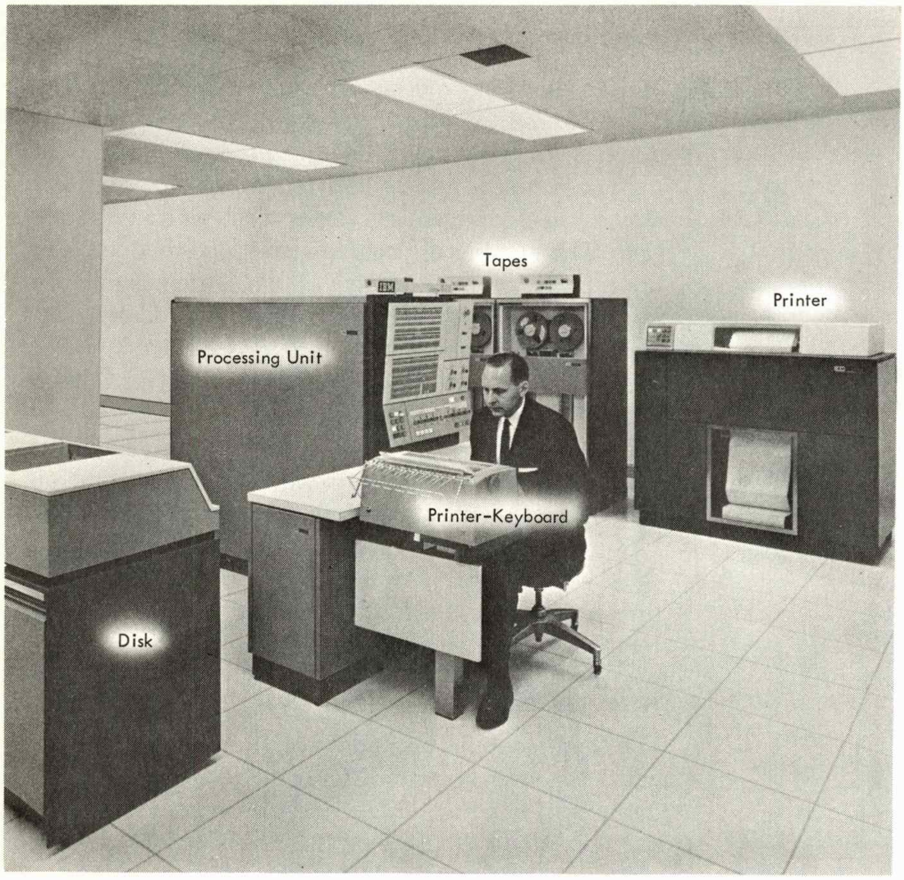


Figure 3. IBM System/360 Model 30

two LCS units and partially overlapped, with the effect, on Models 65 and 75, of increasing the maximum sequential access speed from a rate of 1 megabyte per second (8-microsecond speed with eight bytes per access) to 2 megabytes per second (4-microsecond effective rate). In Model 50, only four bytes are fetched per storage access, and interleaving can be specified only where LCS is to be shared with a Model 65 or 75 in a System/360 multisystem. (See "Communication Among CPU's.") When interleaving is specified, available LCS capacities are, in round numbers, 2, 4, or 8 million bytes.

Shared Main Storage

Processing units may share either processor storage or large-capacity storage; the two capabilities are separate. The first permits the processor storage associated with two or more processing units to be shared and addressed by each as a single processor storage. At present this feature is available only on the Model 67.

The shared processor storage feature enables up to four Model 67-2 CPU's to share processor storage, and each CPU to address as many as 2,097,152 bytes of the high-speed processor storage. (The processor storage capacity for Model 67 is achieved with as many as eight storage units, at 262,144 bytes per unit.)

LCS, available for Models 50, 65, and 75, can be shared among two or more systems. Conditions for LCS sharing are: a Model 65 or 75 can share LCS with any Model 65 or 75 that has equal processor storage. A Model 65 or 75 can share LCS with a Model 50 that has equal or smaller processor storage. A Model 50 can share LCS with any other Model 50, regardless of processor storage size.

Arithmetic

Decimal Arithmetic

The System/360 performs decimal arithmetic on signed decimal numbers packed two digits (or one digit and sign) per byte. Decimal operations are performed storage-to-storage: that is, not through a general register or (thus) restricted to the register's four-byte length. The length of a decimal field is specified in the instruction; the maximum length is 31 digits and sign, all packed in 16 bytes.

Binary Arithmetic

The System/360 has 16 general registers that can be used for binary addition, subtraction, multiplication, and division; their primary use is in computing and modifying addresses within the program. The registers are all four bytes long, though two registers are sometimes coupled: for example, to preserve precision of the products and quotients in multiplication and division.

Floating-Point Arithmetic

When floating-point instructions are added to or included in the instruction set, four additional registers are provided with the system; all are eight bytes long; all floating-point arithmetic is done in them. The floating-point operations use the 16 general registers for indexing and address arithmetic.

The floating-point representation, which is basically a mathematical shorthand that reduces numbers to a fraction and a characteristic (exponent), can express decimal values ranging from about 5.4×10^{-79} to about 7.2×10^{75}. The use of floating-point greatly increases the speed and efficiency of computations.

The System/360 floating-point feature includes both short precision (four bytes) and long precision (eight bytes), for the use of either at the programmer's discretion. Short precision is used to minimize execution times and maximize the number of factors in storage. Long precision is used when greater precision is desired; all models have both precisions available and operate identically.

When floating-point arithmetic is added as a special feature on the Model 44, a unique feature, variable long-precision, is also provided. This feature enables the user to vary precision to suit his needs. By setting a switch on the system control panel, the user can adjust long-precision instructions to provide answers of 5, 6, 7, or a full 8 bytes of precision. As the specified precision is reduced, instruction execution time is reduced correspondingly.

Instructions

Most instructions in the IBM System/360 have two data addresses; either address may be a register address or a storage address. Depending on the operation to be performed, instructions are two, four, or six bytes long.

The *standard* set of instructions provides the basic processing and logical instructions of the system. The addition of decimal arithmetic and editing facilities—important in commercial applications—forms the *commercial* set. The addition of floating-point instructions to the standard set forms the *scientific* set.

Two instructions are provided for the protection features, and two are provided for the direct control feature. The *universal* instruction set, a standard facility on Models 50-75 and optional on Models 30 and 40, includes the standard set, the decimal, the floating-point, and the two instructions to control protection of storage. Model 91 includes all these except six of the decimal arithmetic instructions (which, however, it performs with subroutines).

The Model 67 instruction set includes four instructions unique to the Model 67, all used for the provision of time sharing. The Model 44 instruction set can include four instructions unique to the Model 44: two for its direct word special feature, and two for its priority interrupt special feature. The Models 75 and 91 include the two instructions for direct control that are a special feature for Models 30, 40, 50, 65, and 67.

Compatibility Among System/360 Models

System compatibility ensures the easy growth to a larger model, whenever the user finds that necessary, with continued utility of his programs. The facility exists at any time to use small models to back up large ones—within the limits of compatibility.

Except for Models 44 and 67, the models of the IBM System/360 described in this publication are fully instruction set compatible with one another. This means that programs that operate on one model will operate on other models that have the required configuration of equipment. Compatibility may be lost where execution of a program depends on internal timings or the relationship between internal timings and input/output speed.

The Models 44 and 67 are carefully disciplined departures from total compatibility. Compatibility is maintained, however, in all but those areas that conflict with the specialized functions of these models. Model 91 departs only slightly from complete compatibility, as described below.

Model 44

The basic Model 44 is unilaterally compatible with System/360 Models 30 through 91. That is, a program written for the basic Model 44 can be executed on any of these other models if the compatibility constraints of System/360 are observed.

The Model 44 excludes 19 instructions that are normally included in the standard instruction set; these are the decimal arithmetic and other variable-field-length instructions. On the scientific, data acquisition, and process control problems for which its instructions were selected, the Model 44 performs from 30 to 60% faster than the Model 50.

Programs that depend on special features available for only the Model 44 (direct word, priority interrupt, direct data channel, and the selection of less than eight bytes for long-precision floating point) cannot be run on any other System/360 model.

For particular reference to Model 44, see "Channels," "Direct Control and External Interruption," and "Single-Disk Storage Drive."

Model 67

The time-sharing capability enables the Model 67 to be switched among many users' programs and to process them with apparent simultaneity, so that each user, although he is allotted only his portion of the processing time, can operate as though he had exclusive access to the system.

The Model 67 may be operated under either the Time-Sharing System (TSS) or the System/360 Operating System (OS), but not both simultaneously. (See "Programming Systems.") Programs written for time-sharing operation on the Model 67 cannot be run on any other System/360 model. Except for the additional features, the Model 67 is completely compatible with the remaining models of the system.

For particular reference to Model 67, see "Channels," "Communication Among CPU's," and "Time Sharing."

Model 91

Model 91 is primarily for activities such as global weather forecasting, nuclear physics, space exploration, and other large-scale scientific and business operations in which ultra-fast processing is required. It achieves between five and fifteen times the performance of Model 75 in floating-point operations. Its performance results from new circuit packaging and storage techniques, new algorithms (methods of calculation), and the concurrency of internal operations.

For example: the CPU fetches a number of instructions ahead of execution, and is usually able to fit instruction fetching into "slack" periods between data fetching and storing. After instruction decoding, the work is distributed to several independent subunits. Buffered coupling exists among these functional entities and, in each, several operations may be performed at one time.

When instructions are logically independent, they are often performed out of sequence; and several instructions may be executed in parallel. System/360 coding may be processed, however, without any special program optimization outside the CPU.

The only exceptions from full compatibility are:

1. Six of the eight decimal arithmetic instructions (all but EDIT and EDIT AND MARK) are not provided; instead, they are simulated by interpretive subroutines.
2. In the results of floating-point division, an incompatibility with the other models is, at worst, an amount equal to a one bit in the low-order fraction position.
3. Several program interruptions do not save the address of the causative instruction, and several instructions may be executed before such an interruption can be honored.

For particular reference to Model 91, see "System Controls" and, under "Visual Input/Output," see "Unique Equipment."

For further details concerning the general compatibility constraints, see *IBM System/360 Principles of Operation,* Form A22-6821; for further details concerning a specific model, see *IBM System/360 Bibliography,* Form A22-6822.

Open-Ended Design

One of the chief lessons of the last decade of data processing is the desirability of open-ended design. The System/360 was designed in this way, and therefore lends itself to taking maximum advantage of new technology, new I/O devices, etc. A simple example of open-ended design is the capability of addressing as many as 16,777,216 bytes of storage, thereby anticipating still larger storage needs than those already met; another is the continuing reservation for new blocks of operation codes.

Interruption System

To make maximum use of a modern data processing system, some automatic procedure must be made available to alert the system to an exceptional condition, the end of an I/O operation, program errors, machine errors, etc., and send the system to the appropriate routine following the detection of such an event. The system must have, in effect, the ability to pause to answer the telephone and then to resume the interrupted work. This automatic procedure is called an interruption system.

Also, a main requirement for systems attempting to handle communications is the ability to be interrupted in any task in order to take on a task of higher priority.

The efficiency of any interruption system is based on the amount of time it takes to safekeep the reminders of where it was at the time of interruption, switch to the interruptive work, and then switch back to the interrupted work. This is done in the System/360 by one of the most advanced and efficient interruption systems ever conceived, suitable for the most rigorous demands of communication systems. (For further details, refer to "Interruption and Program Status Word.")

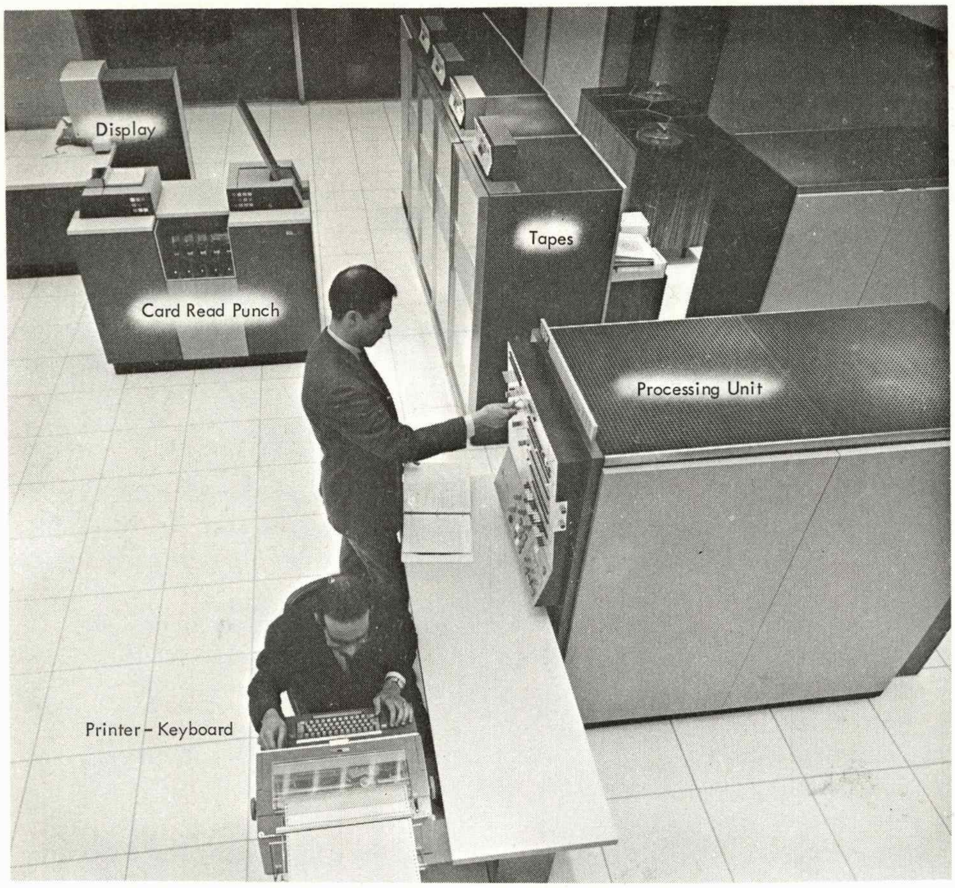


Figure 4. IBM System/360 Model 40

System Accuracy and Reliability

On all models of the system except Model 44, data and instructions are monitored for invalid information by parity-checking throughout the system. Model 44 employs parity-checking in storage and in the channels. Also, reliability is an inherent advantage of solid logic technology.

Programs are checked as they are executed. Because any interruptions caused by machine or program errors are at once classified by the interruption system and are treated differently, program errors cannot create machine errors; in this way, the causes of malfunctions can be and are clearly separated.

The compatible design of the System/360 makes it easy to couple together, either permanently or temporarily, a special system containing redundant I/O, storage, and processing units; thus, the expanded system can be made capable of operating even when components fail.

Universal Code Capability

The use of eight information bits for each character means that the System/360 can accept most character codes now in use or planned. The system provides defined operations for processing either the extension to the widely used BCD interchange code (EBCDIC) or the U.S.A. Standard Code for Information Interchange (USASCII).

An additional advantage of the eight bit character for alphameric data is the ability to pack two decimal digits in each byte, providing high data-packing efficiency in storage and on tapes and disks. Such packing is possible because decimal digits require only four information bits each, and is implemented because decimal data occur in business records more than twice as frequently as alphameric data.

Channels

All devices used for system input and output—card readers, printers, magnetic tape units, etc.—are associated with control units. Control units are sometimes physically integrated with their devices and sometimes not; they may be separately numbered machines or, in a few instances, adapters located inside the processing unit or elsewhere.

More importantly, any device and its control unit should be viewed as together providing a type of I/O function, with the role of the I/O control unit being assumed and understood. From the system viewpoint, the synchronizing, code translating, or other control-unit functions are characteristically attributed to the device.

Therefore, in this manual the control unit, however important its intermediary functions, is conceptually treated as a window through which the processing unit looks toward the end functions actually manifested in the device. Moreover, an elaborate data path and gating controller, called a channel, is always situated between the processing activities and that window.

The only important distinction made between control unit and device occurs where many devices of the same or different type, or many communication lines, are associated with a single control unit (which is said to be, then, of the "shared path" or "multipath" type). In such cases, the more important ramifications are described; but in any given operation the specific device and the control unit for it are viewed as functionally one.

Each System/360 channel directs the flow of information between the processing unit's main storage and the I/O equipment that the channel controls. The channel therefore relieves the processing unit of the tasks of directly communicating with I/O, and permits data processing to proceed concurrently with input/output operations.

System/360 channels are of two general types: multiplexer and selector.

Multiplexer Channel

The multiplexer channel, a completely new concept in data channels, separates the operations of high-speed devices from those of lower-speed devices. Operations on the channel are in two modes: a "multiplex" mode for lower data rates, and a "burst" mode for the higher.

In the multiplex mode, the single data path of the channel can be time-shared by a large number of low-speed I/O devices operating simultaneously; the channel receives and sends data to them on demand. The effect is of subdividing the data path into many subchannels (as many as 256). To the programmer, each such subchannel is a separate channel, and can be programmed as such. A different device may be started on each subchannel, and controlled by its own list of channel commands. (Refer to "Control of I/O.")

Examples of low-speed devices that can operate simultaneously on the multiplexer channel are:

Printers
Card Punches
Card Readers
Terminals

The 2702 Transmission Control can transmit messages to the System/360 from many remote 1050 terminals, for instance, all of which may be operating intermittently or even simultaneously, but at relatively low data rates.

The burst mode is forced by devices such as magnetic tape units and disk, drum, or data cell storage; it is not under the control of the programmer. Such high-speed devices, having established a logical connection with a channel, usually stay connected to it for the duration of data transfer and thereby force the channel into its burst-mode state.

In the multiplex mode, data processing takes place while data are being transferred, thus increasing throughput by overlapping channel operations with processing. In the burst mode, processing is not overlapped in Models 30 and 40 but is overlapped in Models 44-91.

A multiplexer channel is a standard feature of Models 30, 40, and 50, a special feature for Model 44, or available as the IBM 2870 Multiplexer Channel for Models 65-91.

On the Model 44, the multiplexer channel may be installed together with one or two special high-speed multiplexer channels; one channel (either type) is required.

A maximum of eight I/O control units may be attached to any type of multiplexer channel except the IBM 2870, to which as many as 40 may be attached.

On the Model 67-2, which usually contains more than one CPU, more than one multiplexer channel may be installed. Further, more than one multiplexer channel (the 2870) may be installed per CPU; however, only one 2870 per CPU may attach more than eight control units.

For details, see "Particulars on Multiplexer Channels."

Selector Channels

Selector channels transmit data to or from a single I/O device at a time and are capable of handling high-speed I/O devices. Each selector channel attaches up to eight I/O control units and can address as many as 256 I/O devices. One I/O device per selector channel can be transmitting data at any given time; no other I/O device on the channel can transmit data until all data are handled for the selected device. With two or more channels, read/write/compute is possible. All selector channels might be reading or writing, or some reading and others writing, with or without simultaneous operation of the multiplexer channel, while processing also takes place.

In general, I/O operations on a selector channel are overlapped with processing, and all channels can operate simultaneously, provided only that the processing unit's data rate capabilities are not exceeded. Nominal data rates for the selector channels range from 250 thousand bytes to 1.3 million bytes per second, depending on the system model and the channel options selected.

A unique case is the direct data channel (DDC), available for Model 44 as a special-feature data path to non-IBM external devices. This channel has a data transfer capability of at least one megabyte per second, or half that if a high-speed multiplexer channel is also working; when controlled to obtain exclusive access to main storage after the initiating steps, and when no chaining is used, the data rate is as high as four megabytes per second. (For a discussion of chaining, see "Control of I/O.") The DDC has the same control-unit attachment capabilities as the conventional selector channels, and is controlled by the same instructions and commands.

All selector channels are optional equipment. (On Models 65-91, either a selector channel or multiplexer channel is required.) The number of selector channels on a given model ranges from zero to two for Models 30 and 40, zero or only one (the DDC) for Model 44, zero to three for Model 50, zero to five for Model 91, and zero to six for Models 65, 67-1, and 75.

With the Model 67-2, channels are attached via the IBM 2846 Channel Controller. The number of channels attached by a 2846—from one to seven—is the same as may be attached directly to Model 67-1. Unlike the 67-1, which has a maximum mix of one multiplexer channel and six selector channels, the 67-2 may have more than one multiplexer channel per CPU; the maximum number depends on the type and number of I/O devices attached to each multiplexer channel.

From one to four IBM 2846 Channel Controllers may be attached to a Model 67-2, providing for as many as 28 concurrently operating channels in all.

Communication Among CPU's

Several systems of the same or different models may be combined into a multisystem. Three levels of communication among processing units are available. Largest in capacity and slowest in speed is communication via a shared I/O device; for example, a shared disk or drum storage. Faster transmissions are obtained by the direct connection between channels afforded by the channel-to-channel adapter. Finally, storage may be shared as described under "Shared Main Storage." These modes of communication can be supplemented by the direct control feature. See "Direct Control and External Interruption."

Channel-to-Channel Adapter

The purpose of the channel-to-channel adapter is to interconnect two selector or multiplexer channels; primarily, it is to connect a selector channel on one system to a selector channel on another system. It may

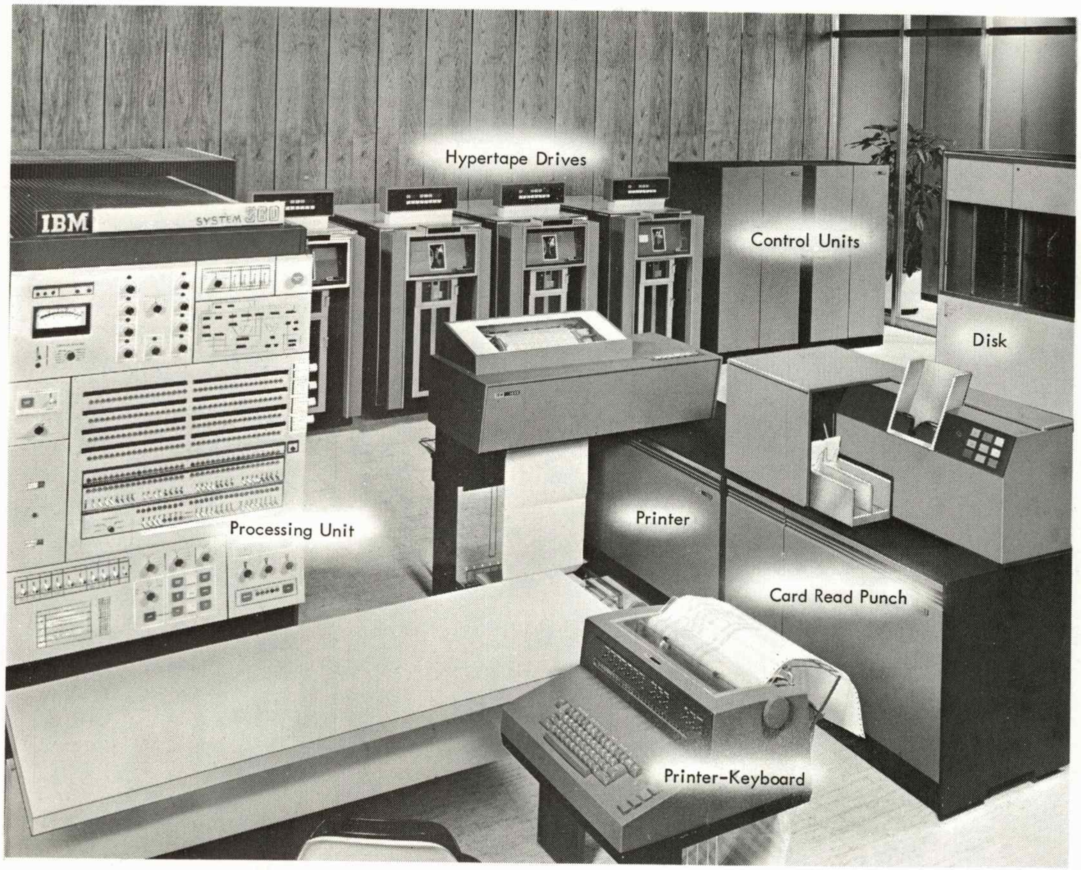


Figure 5. IBM System/360 Model 50

also connect two channels on the same system, for moving blocks of data from one area to another in main storage (while processing continues). Data transmission is at the rate of the lower-speed channel.

When intersystem communication is provided by means of this adapter, each system appears like I/O equipment to the other. The adapter is selected by either channel the same as any control unit, and the ensuing channel commands both clear a path between the two channels and synchronize their operations.

On Models 30, 40, and 50, one adapter may be installed per CPU. On Model 44, no channel-to-channel adapter may be installed. On Models 65-91, an adapter may be installed for each selector channel installed. An adapter cannot be installed on a 2870 Multiplexer Channel. Because the adapter is physically installed on only one of the two channels being interconnected, however, at least three expansions are feasible:

1. More than one channel connection may be made for a particular Model 30, 40, or 50 if the additional adapter needed is physically installed on the other system.
2. A Model 44 can be so connected to another system if the adapter is installed on the other system.
3. A 2870 Multiplexer Channel can be so connected to another channel if the adapter is installed on the other channel.

Partitioning Model 67-2

A Model 67-2 that has sufficient elements may be partitioned into at least two independently operated systems. This can be achieved by programs that refer exclusively to certain components, but it is more desirable to partition components from the rest of the system by means of centrally located controls.

Such a means is provided by the IBM 2167 Configuration Unit, a console-like component on which the partitioning switches and indicators are located. If the Model 67-2 has multiple processing units (the usual case), partitioning from the required 2167 provides for their operation as one multisystem (basic) or as independent systems. If one or more components become inoperative, partitioning permits them to be bypassed for continuing service.

Time Sharing

The Model 67 provides System/360 with the time-sharing capabilities that permit multiple access, enabling many users at remote terminals to employ the system as if each were its only user. The computer

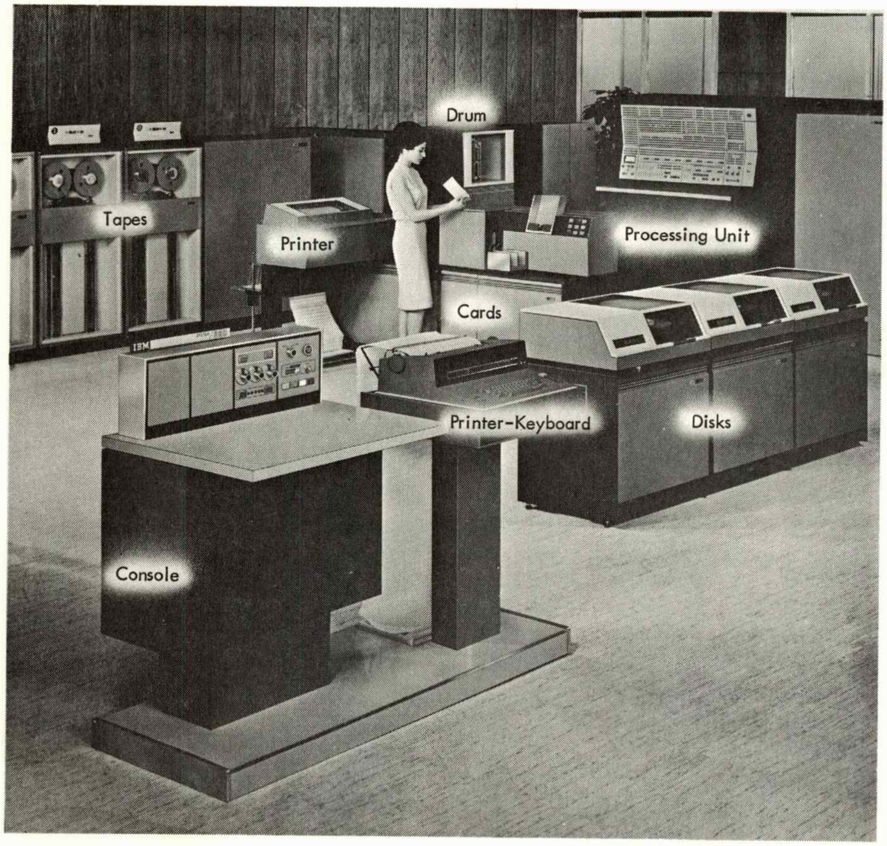


Figure 6. IBM System/360 Model 75

may actually be switching among many terminals and processing many programs, giving each terminal a small slice of its available time. Time sharing is especially applicable to scientific and engineering problems, where the computations are not usually of a repetitive nature, and it is advantageous to enter a problem piecemeal into the computer and observe intermediate results before proceeding with the computation.

The Model 67 can provide apparently simultaneous operations to more than 200 users at remote terminals. It can operate in this time-sharing mode 24 hours a day and process batch jobs during the time available between calls from remote terminals for computing.

Dynamic Address Translation

With so many users having access to main storage, it is quite possible that at any one time the size of all programs being processed may exceed the capacity of main storage to accommodate them. Dynamic address translation, a combination of advanced programming and circuitry, permits each user to program as though he had sole use of a large, contiguously addressable "virtual" storage area; on the Model 67 this area is about 16 million or 4 billion bytes, depending on whether the standard or the special extended dynamic address translation feature is chosen.

Only the active parts of programs reside in core storage; the remaining parts are disposed on secondary storage devices. When these parts are called into core as needed, they are put in any available location. Although this procedure is quite complex, it is automatic and places no burden on the programmer, who can remain unaware that he is not the sole user of the system.

Flexibility in Speed, Storage, Features, and I/O

The variations in system models, core storage capacity, optional features, and I/O configuration provide a flexibility that permits the system to be tailored to suit the individual user's exact requirements—with the added advantage of system growth without reprogramming.

The possible combinations of units and features, with distinctions between standard and optional features on different system models, are shown in the *IBM System/360 Configurator:*

Model 30: Form A24-3232
Model 40: Form A22-6813
Model 44: Form A22-6874
Model 50: Form A22-6814
Model 65: Form A22-6887
Model 67: sample in Form C20-1647
Model 75: Form A22-6888
Model 91: in Form A22-6907
Input/Output: Form A22-6823
Communications and Acquisition: Form A22-6824
Details on 1827: Form A22-6872

Magnetic tape units and disk storage units can be employed in various combinations as high-speed I/O and for storing vast amounts of data in tape and/or disk libraries.

Input/output also includes data communications services, magnetic character readers, visual displays, many choices in rate and type of card input and card or printer output, voice output, and the numerous other I/O capabilities described under "Input/Output Devices" and "System/360 Teleprocessing Data Acquisition, and Process Control."

Standard Connections for I/O Devices

The physical connection between I/O devices and the channels is called the "I/O interface." All devices, regardless of their differences, can be connected to the system without adding new instructions to the processing unit or new channel commands. Basic control of devices of the future will be via the interface; consequently, I/O interface also represents an instance of open-ended design.

Direct Control and External Interruption

For all models of the system except Model 44, direct control provides a means of exchanging control signals between two System/360 processing units, or between a System/360 and some specialized device such as an analog-digital converter.

Direct control bypasses the channel. It is effected by the use of direct-control instructions (READ DIRECT and WRITE DIRECT) and external interruption lines. In Models 30 and 44, an external interruption feature is also available, alone, for users who do not require (or have) the direct-control instructions but do require very fast program response to interruptions from time-dependent I/O devices such as the 1419 and 1428.

Direct Word and Priority Interruption

Direct word, instead of direct control, is available for the Model 44. The two features are similar, but direct word has no interruption lines and also differs significantly in passing four bytes at a time rather than a single byte.

Direct word is a special feature primarily intended for the direct exchange (bypassing the channel) of control signals between the CPU and a variety of non-IBM external devices in the function of data acquisition. It is controlled by two instructions: READ DIRECT WORD and WRITE DIRECT WORD.

The priority interrupt feature provides even faster response times than external interruption, and has the power of identifying as many as 256 external conditions at each of its 32 levels. These functions are independent of those of the single-level, six-line external interruption feature (which may be installed together with priority interrupt).

Priority interrupt is primarily intended for the distinguishing of many external situations involving non-IBM equipment; with a minimum of programming, it permits immediate physical branching to an unusually large number (8,192) of response routines. Priority interrupt is controlled by two instructions: LOAD PSW SPECIAL and CHANGE PRIORITY MASK.

The direct word and priority interrupt features are available for the Model 44 only.

Ascertainment of Times and Intervals

The timer for the System/360 is one of two types: a line-frequency timer, or a high-resolution timer. Either type can be used as an interval timer to measure elapsed time, or programmed to tell the time of day. Either timer can measure the duration of each job, poll a communication network at regular intervals such as every minute or 15 minutes, offer the time for stamping program completions, and perform many other tasks.

The line-frequency timer is counted down every 1/50th or 1/60th second. For the high-resolution timer, an oscillator produces decrementations at about 13 microsecond intervals.

Whenever time runs out, an external interruption occurs automatically. The time runs out precisely when decrementations of a count cause the timer to pass from a positive value (including zero) to a negative value. The full duration for either timer, from maximum stored value to the time when the interruption signal is generated, is 15.5 hours.

The line-frequency timer is available for all but Model 67: as a special feature for Model 30 or as a standard feature of Models 40-65, 75, and 91. The high-resolution timer is available for only Models 44 and 67: as a standard feature of Model 67 or as a special feature, replacing the standard line-frequency timer, on Model 44.

System Controls

Manual control over the system is concentrated at the system control panel. The panel is attached to the processing unit and its controls are in three classes, related to function: operator control, operator intervention, and field engineering maintenance. The operator controls are identical, and the operator intervention controls are similar, for all models; the field engineering maintenance section for each model is unique.

The need for manipulation of controls by the operator is held to a minimum by the system design and the control program. Though the operator has access to a rather large number of controls for intervening in the normal programmed operation, the basic controls needed are those contained in a small area on the system control panel: power on, power off, an interrupt key, several lights, and the controls to select an input device for initial program loading.

On Models 50-91, these operator controls can be duplicated at a console located elsewhere in the computer area. (See "IBM 2150 Console" and "IBM 2250 Display Unit Models 1 and 3.")

On the Model 91, all system controls are situated on a unique stand-alone console (considered part of the CPU), where they are used in connection with a display console similar to an IBM 2250 Display Unit Model 1. (The display console, as well as providing obvious visual conveniences, can answer the need to transfer messages between the system and the operator as quickly as is commensurate with the ultra-fast processing of the 91.) A second set of operator controls can be added on this local panel to control another CPU. As indicated above, the operator controls can also be duplicated at a remote console.

Compatibility with Other IBM Systems

A number of features are available that permit the operation of certain models of the System/360 by the use of programs written for other IBM systems. These compatibility features are combinations of circuitry and programming that make the System/360 able to read programs written for the other system and to function like that system. In many cases, the program runs much faster on the System/360 than on the system for which it was written.

Compatibility features are also called emulators, but not simulators. The latter, although they may perform the same function, do so with programming alone and thus run slower.

A compatibility feature is particularly useful when the user needs time to convert his present programs to the System/360 code but, at the same time, wants the advantages offered by the System/360. In addition, using such a feature may eliminate the need for converting programs that are seldom used.

Sufficient storage and appropriate or equivalent I/O devices must be available for the use of a compatibility feature. Furthermore, the use of one compatibility feature precludes the use of another, with one exception: on Models F40-H40, both the 1401/1460 and the 1410/7010 features can be installed as a "dual emulator" system. Under unusual conditions, a feature may not be able to maintain exact compatibility; for example, programs that are time-dependent may not yield identical results, and the handling of error conditions may differ.

Following is a list of the compatibility features presently available, and of the models of the System/360 in which they may be incorporated if minimum and matching configuration requirements are met. For publications giving details on the specific types of compatibility, see subject code 35 in *IBM System/360 Bibliography*, Form A22-6822.

COMPATIBILITY FEATURES	SYSTEM/360 MODELS*
1401/1440/1460	C30-F30
1401/1460	E40-H40
1620	D30-F30
1410/7010	F40-H40, F50-I50
7070/7074	H50-I50, H65-J65
7080	H65-J65
709/7040/7044/7090/ 7094/7094II	I65-J65, 67-1, 67-2

*For processor storage capacities of these models, see Figure 2.

Programming Systems

The System/360 programming support supplied by IBM is aimed at minimizing the time and effort required by the user to produce and process programs. Programming support ranges from relatively simple programs to highly sophisticated operating systems. It falls in three categories:

1. Basic Programming Support
2. Special Systems Support
3. Operating Systems

Basic Programming Support (BPS)

The BPS programs provide support for minimum card and tape configurations. BPS furnishes a large number of independent programs, each performing its specific functions, and provides translators for the following programming languages:

Assembler
Report Program Generator (RPG)
FORTRAN

BPS also includes utility programs (e.g. write tape to cards, write disk to tape), sort/merge programs, and Autotest (a program testing and patching facility). Other BPS programs support applications for optical and magnetic character readers.

Most BPS programs require only 8K of main storage. (One K = 1,024 bytes.)

Special Systems Support

Model 44, a scientific and engineering system, and Model 67, a time sharing system, are the object of special programming support consistent with the particular applications of these systems.

Operating Systems—General Facts

An operating system is a collection of programs that provides for the preparation and execution of the user's problem programs (jobs). IBM-supplied operating systems are designed to match the needs of the equipment configuration and the customer's job requirements.

All operating systems are either tape-resident or direct-access-resident and consist of two basic parts:

Control program
Processing programs

Control Program

The control program is the framework of an operating system; it has three distinct functions:

Job management
Task management (Supervisor)
Data management

Job Management provides the facilities to read, interpret, initiate, and terminate jobs submitted for processing. It also provides the facilities for the operator to communicate with the system.

Task Management is the core of an operating system. Because it performs the supervisory functions associated with the execution of a task, it is often called the supervisor. (See Figure 7.) The functions provided generally include interruption handling, main storage allocation and space accounting, fetching of non-resident routines, time supervision, and transient error recovery.

Data Management provides the functions of record blocking and deblocking, space allocation on direct access devices, processing of labels, and the transfer of data between main storage and external devices, all by means of various *access methods.* These functions allow data sets (sometimes called data files) and their processing the utmost independence from the I/O environment. The access methods used are well-defined and consistent ways of handling data sets according to their basic organization: sequential, indexed sequential, direct, partitioned, etc. Some access methods provide automatic buffering facilities.

Processing Program

A processing program is defined as any program that is not a control program. Processing programs are kept on tape or direct access devices, as collections of data sets known as libraries, and fall in three general categories:

1. *Language Translators* for Assembler, FORTRAN, COBOL, Programming Language I (PL/I), etc.

2. *Service Programs* such as utilities and sort/merge.

3. *User-Written Problem Programs* that become part of the operating system library and are retrievable by name alone.

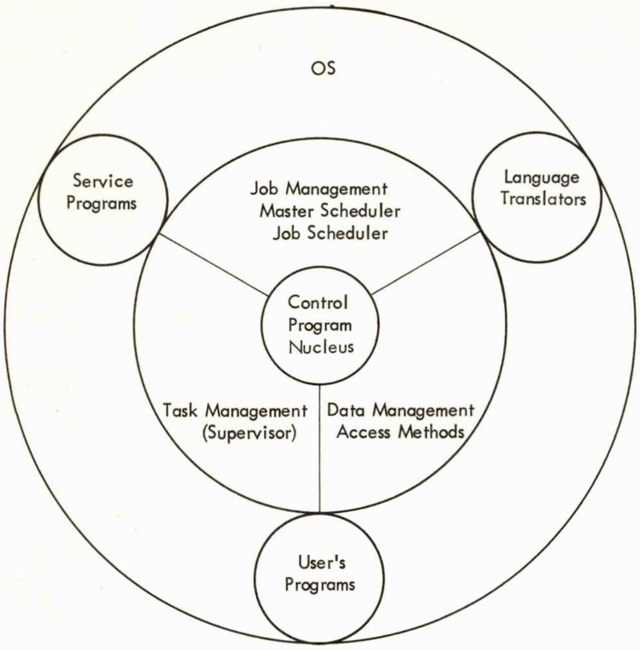


Figure 7. Encompassment of an Operating System, Using Terminology of OS

Specific Operating Systems

The operating systems supplied by IBM have been designed in modular fashion so that functions may be incorporated according to the need of the user and the size of his equipment configuration. The operating system is created and integrated with the equipment at the time of installation during an operation called *system generation*.

The four IBM-supplied operating systems for the System/360 are:

1. System/360 Basic Operating System (BOS)
2. System/360 Disk Operating System (DOS)
3. System/360 Tape Operating System (TOS)
4. System/360 Operating System (OS)

BOS is resident on IBM 2311 Disk Storage in a System/360 having at least 8K of main storage. In addition to a control program, BOS includes Assembler and RPG language translators, utilities, a disk sort/merge program, and Autotest.

DOS/TOS are 2311 disk- and 2400 series tape-resident, respectively, in a system having at least 16K of main storage; however, to realize the full potential of either DOS or TOS, at least 32K is recommended. These operating systems offer additional functions commensurate with progressively larger systems; they also provide facilities for multiprogramming and (with DOS) teleprocessing. Each provides a control program, five language translators (for Assembler, RPG, FORTRAN, COBOL, and PL/I), utilities, sort/merge programs, Autotest, and special-purpose librarian programs—including those for the maintenance of and printed/punched output from libraries. TOS provides a multiprogramming facility that permits the simultaneous execution of two or three programs. DOS also permits multiprogramming, and provides communications functions through Basic Telecommunications Access Method (BTAM).

OS is the most sophisticated and the most powerful of the operating systems. It is designed for use on most systems among Models 50 and larger. It is not for use on Model 44, which has unique programming support. It may be used on Model 67, but only when the special Time-Sharing System for that model is not in use. With the sacrifice of a few functions—perhaps not needed for a particular installation—OS can be integrated in a system having as little as 32K of main storage. To take advantage of most options, however, at least 64K is required; the storage size must be estimated for each system or multisystem according to the OS facilities actually needed. OS is resident on direct access devices having a data rate that the using model of System/360 is capable of accepting. (See Figures 32 and 52.)

The facilities of BOS, DOS, and TOS are depicted in Figure 8. A diagram of OS is available on a card in color; see *Operating System/360 Chart,* Form V25-6156.

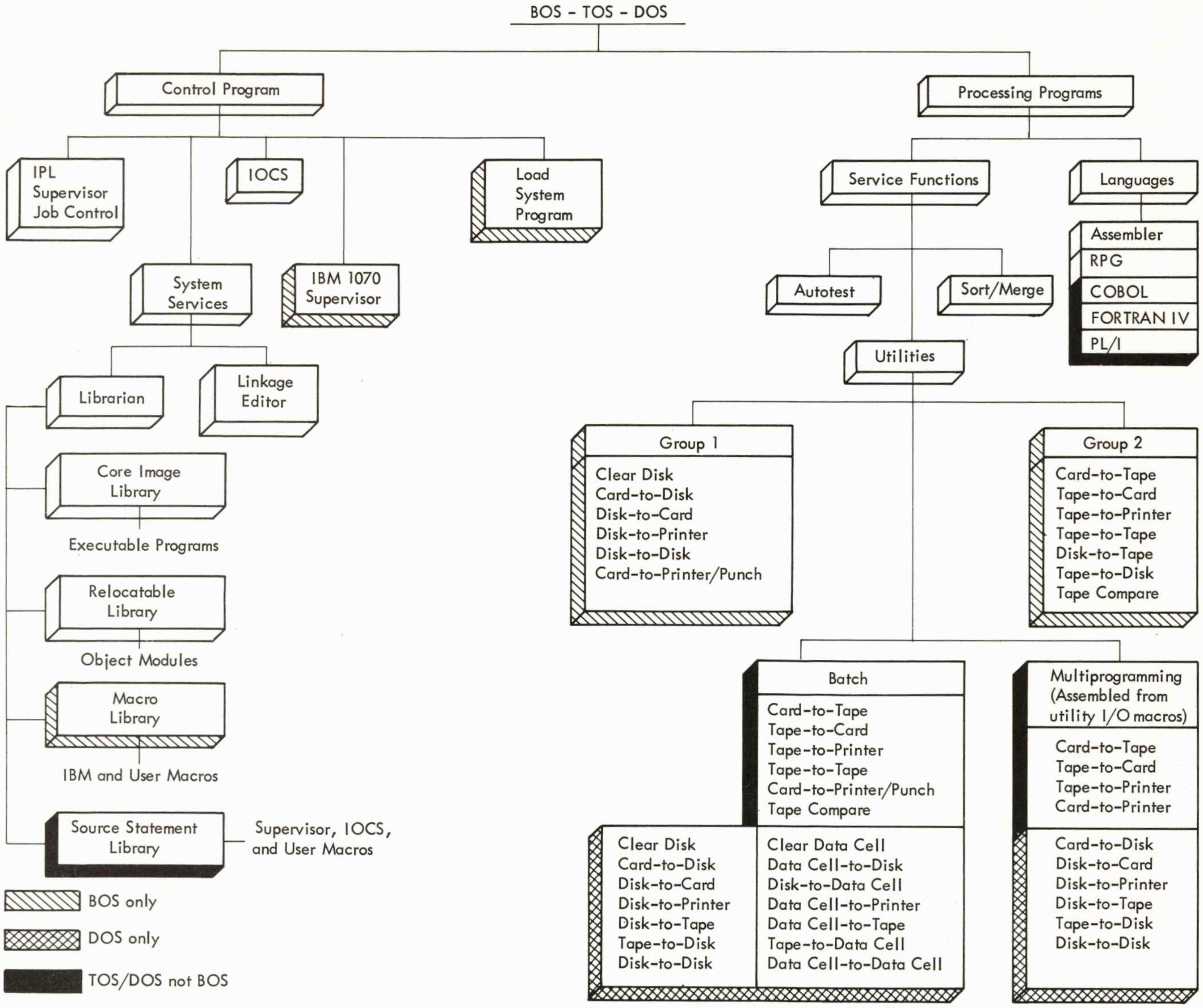


Figure 8. Facilities of BOS, TOS, and DOS

System Methods

This section summarizes several important distinctions of the System/360 and enlarges on several of the system concepts previously discussed.

Main Physical Arrangement

The Processing Unit houses the facilities for decoding instructions and addressing storage, for arithmetic, logical processing of data, and for instructing channels to communicate with input/output devices.

Processor Storage may be either physically integrated with the processing unit or separate from it, depending on the model. No logical differences are entailed.

Channels, likewise, may be either physically integrated with the processing unit or separate from it, depending on the model, as shown in the system configurators. When integrated with the processing unit, the channels share, to some extent, the processing unit circuits, resulting in cost and performance differences without differences in logical function.

The System Control Panel is attached to the processing unit (Figure 9) or, in the case of the Model 91, to a special console considered part of the processing unit.

Machine Addressing

Data in core storage are usually thought of as being physically stored in a table or block, with the positions of individual items being relative to the block origin. The System/360 makes use of this approach.

To this end, a two-part address format is used, with each address making reference to a base (the origin) and a displacement (the item position as related to that base). The base is given in the general register tagged by the instruction; the much shorter displacement is given in the instruction itself.

Using this approach, the System/360 can address more than 16,000,000 bytes, but without wasting storage by carrying a long data address in each instruction.

Furthermore, many instructions have a three-part address, in which two general registers are tagged —one for the base address and the other for an index —while the displacement is still used. Thus, the System/360 can index throughout a data area, using the displacement for local movement around a data point selected from a changing origin.

Formats

The System/360 has the capability of accepting inputs of many varying formats. Data field lengths may be fixed at one, two, four, or eight bytes, or variable from a minimum of one byte to a maximum of 256 bytes, in increments of one byte. The length of a variable field is specified within the instruction; the length of a fixed field is implicit in the instruction's operation code.

Editing, and arithmetic operations on decimal data, are performed using variable field lengths. Decimal numbers are also packed two per byte to conserve storage space (both main and file) and speed processing. This packing of decimal information also manifests itself in much higher effective I/O data rates.

Decimal numbers may also be changed to, or appear in, a "zoned" format, as required for I/O devices transferring alphameric characters at the time. In the zoned format, one byte contains one character (whether numeric, alphabetic, or special). Decimal numbers are easily changed, by single instructions, from the zoned to the packed format and vice versa.

Interruption and Program Status Word

The interruption system, previously discussed under "System Concepts," makes possible the operation of a system in a non-stop environment and greatly aids the efficient use of I/O equipment. The desire to make the interruption procedure as short and simple as possible means that the method of switching between the interrupted program and the program that services the interruption must be quite efficient. It operates as follows:

The complete status of the System/360 is held in eight bytes of information. This status information, which consists of the instruction address, condition code, storage protection key, etc., is saved when an interruption occurs, and is restored when the interruption has been serviced.

As soon as the interruption occurs, all the status information, together with an identification of the cause of the interruption, is combined into a double (eight-byte) "word" called the program status word (PSW). (In the System/360, a word is one of the units of information and consists of four consecutive bytes within the restrictive boundaries.)

The PSW is stored at a fixed location, the address of which depends on the type of interruption. The system

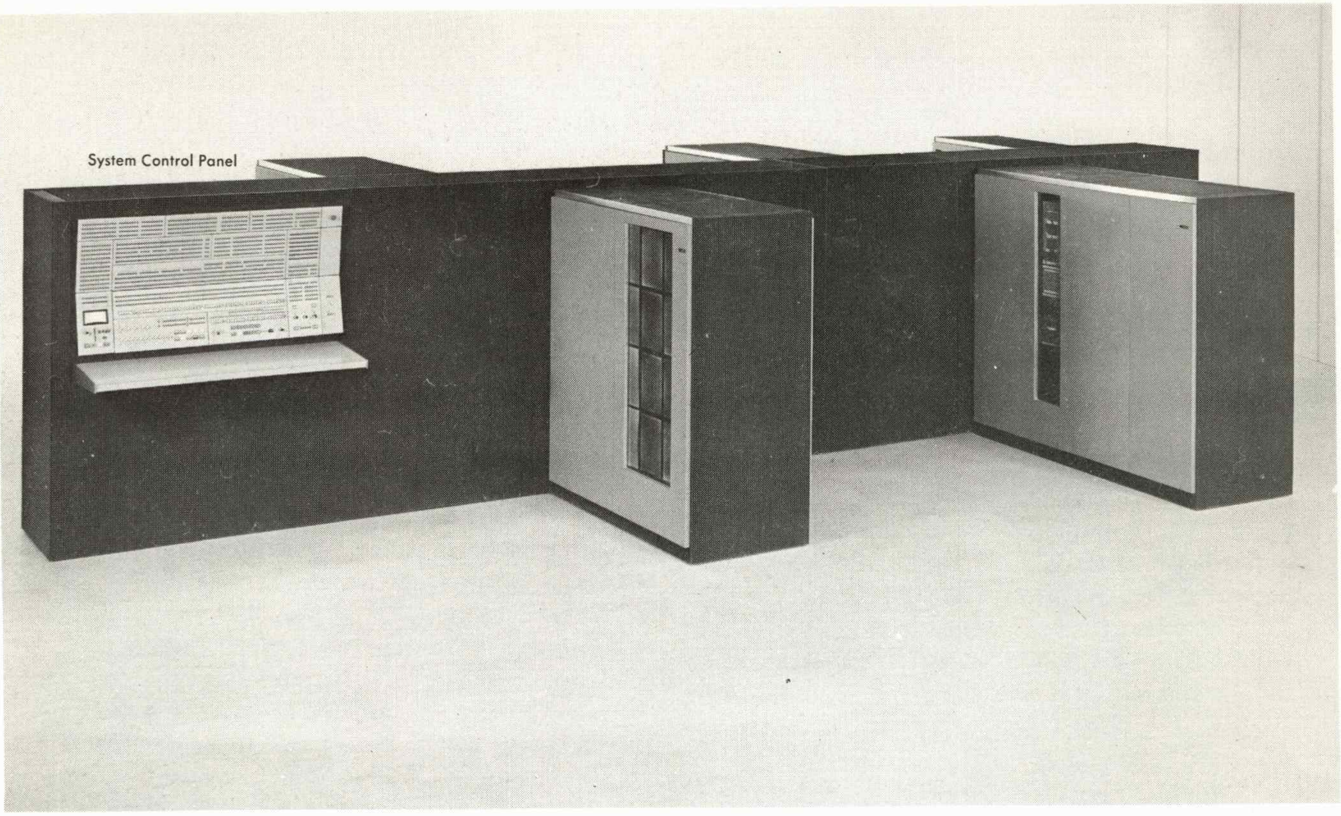


Figure 9. IBM System/360 Model J75, Processing Unit

then automatically fetches a new PSW from a different fixed location, the address of which is also dependent on the type of interruption. Each class of interruption has two fixed locations in main storage: one to receive the old PSW when the interruption occurs, and the other to supply the new PSW that governs the servicing of that class of interruption.

After the interruption has been serviced, a single instruction uses the stored PSW to reset the processing unit to the status it had before the interruption.

The interruption system separates interruptions into five classes:

Program interruptions are caused by various kinds of programming errors; the exact type of error is identified in the old PSW.

Supervisor Call interruptions are caused when the processing program issues an instruction to turn over control to the supervisor in the control program. The exact reason for the call is shown in the old PSW.

External interruptions are caused by either an external device requiring attention or by the timer going past zero. (The external device may be a signal from any device communicating via the direct control feature.)

Machine Check interruptions are caused by the machine-checking circuits detecting a machine error.

I/O interruptions are caused by an I/O unit ending an operation or otherwise needing attention. Identification of the device and channel causing the interruption is stored in the old PSW; in addition, the status of the device and channel is stored in a fixed location.

Disallowing of Interruptions

Most interruptions may be either allowed or temporarily disallowed. When an interruption is disallowed, it is either delayed or does not take place, the alternative depending mainly on the class of interruption. The following can be disallowed:

All of the I/O interruptions,
All of the external interruptions,
Some of the program interruptions, and
The machine-check interruption.

Specifically, while external and I/O interruptions are disallowed, any external or I/O interruption request is held pending until the interruption is allowed. (An interruption request signal is sometimes called, more briefly, an "interrupt.") While program interruptions are disallowed, the corresponding program interruption request signals are disregarded and do not remain pending. While machine-check interruptions are disallowed, the first machine-check interruption request is held pending until the interruption is allowed, and any machine-check interrupt beyond that first one is disregarded and does not remain pending.

Queue

During the execution of an instruction, several interruptive events may occur simultaneously. When this occurs, the competing interruptions are serviced in a fixed order of priority.

Particulars on Multiplexer Channels

The multiplexer channel, described under "System Concepts," makes possible the simultaneous operation of many low-speed I/O devices on the same I/O channel. It also permits one device to operate at a high data-transfer rate.

On Models 30, 40, and 50, the standard multiplexer channel is installed in the CPU. The Model 44 may have as many as two high-speed multiplexer (HSMPX) channels and one multiplexer channel, all within the CPU. As previously described, the multiplexer channel is available for the Models 65-91 in the form of the IBM 2870 Multiplexer Channel, a separate unit.

Notwithstanding differences in speed, number of subchannels, and physical packaging, all multiplexer channels have the same function and operate essentially alike.

The multiplexer channel for Models 30-50 governs as many as eight I/O control units and has a number of subchannels that is basically established by the system model. As the following table shows, the number of subchannels may be expanded in some cases by the addition of an optional feature.

MODEL	PROCESSOR STORAGE	BASIC NO. OF MULTIPLEXER SUBCHANNELS	WITH ADDITIONAL MULTIPLEXER SUB-CHANNELS FEATURE
C30	8,192	32	—
D30	16,384	96	—
E30	32,768	96	224
F30	65,536	96	224
D40	16,384	16	—
E40	32,768	32	—
F40	65,536	64	—
G40	131,072	128	—
H40	262,144	128	—
E44	32,768	32	—
F44	65,536	64	—
G44	131,072	64	—
H44	262,144	64	—
F50	65,536	64	—
G50	131,072	128	—
H50	262,144	128	256
I50	524,288	128	256

Every multiplexer subchannel recognizes a unique device address and can communicate with the device that bears this address. As an alternative on Models 30-50, each of the first eight subchannels can recognize a group of 16 device addresses. This alternative applies only when a shared-path control unit such as a 2803 Tape Control or a 2841 Storage Control is assigned to one of these eight subchannels. Such control units allow only one of their attached devices at a time to be in a data-transferring operation, and can therefore make all their devices share one subchannel. (All control units are classified as shared path, multipath, or single path in Figures 52 and 53.)

When one of the first eight multiplexer subchannels is used with a shared-path control unit, it is called a *shared subchannel.* Otherwise, it behaves like any of the other multiplexer subchannels and addresses only a single device. When, in order to provide for more than 128 simultaneously operating devices, the number of subchannels is extended beyond 128, the shared-subchannel capability is removed and the number of addressable I/O devices (or communication lines, etc.) becomes equal to the number of subchannels.

Distinctions of 2870: On Models 65-91, the IBM 2870 Multiplexer Channel provides 192 subchannels, or 196 if the four selector-subchannels (special features for the 2870) are included. To the eight control units and 192 non-shared subchannels for which the basic 2870 provides, each selector-subchannel adds provisions for up to eight control units or 16 devices, whichever limitation is reached first, and one of these devices at a time may be in a data-transferring operation.

On the Model 67-2, whether it contains one CPU or multiple CPU's, more than one 2870 may be installed. The maximum number of 2870's per CPU depends on the type and number of I/O devices attached to each 2870. Only one 2870 per CPU may have selector-subchannels.

Distinctions of HSMPX Channel: A special feature for Model 44 is the high-speed multiplexer channel. As its name implies, it has higher maximum data-transfer rate capabilities than the conventional multiplexer channel or the 2870. It is available with a single subchannel and may optionally be extended to two, three, or four subchannels.

Each HSMPX subchannel can maintain one data-transferring operation at a time. Each HSMPX subchannel can recognize two device addresses; alternatively, in place of either one (or each) of the device addresses, it can recognize a shared-path control unit with up to 16 device addresses.

Not more than two control units may be attached to each HSMPX subchannel; a subchannel that is not used as a shared subchannel, and can recognize only two device addresses, may be able to support only a single non-shared control unit if both device addresses are used by it.

Control of I/O

Each channel exerts direct control over all of the I/O devices attached to it. However, I/O operations are initiated, halted, or tested (for disallowed I/O interrupts pending) by instructions from the control program. I/O operations are initiated by the START I/O instruction, which selects the device and the channel that are to be used. If they are both available, the channel takes control by fetching a channel command word to direct all details of the operation.

More than one channel command word (CCW) may be associated with a single START I/O instruction. In such an operation, successive CCW's are said to be chained. When *command chaining* is specified, the next CCW initiates a new I/O operation. The ability of successive CCW's to give a sequence of different operations to the device—such as search, read, and write—permits the device to be reinstructed quickly, thereby increasing its effective data rate. When *data chaining* is specified, the successive CCW's are used only to specify other data areas for the original and continuing I/O operation. Data chaining permits information to be rearranged as it is transferred between main storage and the I/O device.

The channel contains the storage required for synchronization with the processing unit, and refers to main storage to obtain or place information. Instruction execution in the main program is not affected, except by the time delay introduced in the claiming by the channel of operating cycles between those used for the execution of program instructions.

The channel indicates the end of I/O operations by signaling for an I/O interruption, storing the device and channel address in the old PSW, and storing certain status information in a fixed eight-byte location. If the processing unit is not interruptible for I/O interruptions, that interruption request is kept pending in the channel; any interrupt queue in the several channels is serviced in the fixed order of priority.

Input/Output Devices

The System/360 at any specific installation consists of the processing unit, its channels, and all on-line I/O equipment. On-line I/O means that such equipment operates under the control of the computer program. The following I/O devices and control units can operate on-line as part of the System/360. Nearly all can be included in any System/360 Model 30 and higher; exceptions for certain models are given in Figure 52. The specific channels for attachment of the devices are included in the figure and are also depicted on the configurators, which are listed on page 15 of this manual and described under subject code 00 in *IBM System/360 Bibliography*, Form A22-6822.

Visual

IBM 2250 Display Unit Models 1 and 3
IBM 2840 Display Control Model 2
IBM 2814 Switching Unit Models 1-3
IBM 2260 Display Station
IBM 2848 Display Control Models 1-3

Manual Controls

IBM 1052 Printer-Keyboard Models 3, 5, 6, 7, and 8
IBM 1051 Control Unit Models 1 and N1
IBM 2150 Console

Tape

IBM 2401 Magnetic Tape Unit Models 1-6
IBM 2803 Tape Control Models 1 and 2
IBM 2804 Tape Control Models 1 and 2
IBM 2415 Magnetic Tape Unit and Control Models 1-6
IBM 7340 Hypertape Drive Model 3
IBM 2802 Hypertape Control
IBM 2816 Switching Unit Models 1 and 2
IBM 2671 Paper Tape Reader
IBM 2822 Paper Tape Reader Control

Direct Access

IBM 2302 Disk Storage Models 3 and 4
IBM 2303 Drum Storage
IBM 2311 Disk Storage Drive
IBM 2321 Data Cell Drive
IBM 2841 Storage Control
IBM 2301 Drum Storage
IBM 2820 Storage Control
IBM 2314 Direct Access Storage Facility
IBM 2844 Auxiliary Storage Control
Single-Disk Storage Drive

Card

IBM 1442 Card Read Punch Model N1
IBM 1442 Card Punch Model N2
IBM 2501 Card Reader Models B1 and B2
IBM 2520 Card Read Punch Model B1
IBM 2520 Card Punch Models B2 and B3
IBM 2540 Card Read Punch

Print

IBM 1053 Printer Models 1 and 4
IBM 1403 Printer Models 2, 3, 7, and N1
IBM 1404 Printer Model 2
IBM 2821 Control Unit Models 1-5
IBM 1443 Printer Model N1
IBM 1445 Printer Model N1

Magnetic Ink

IBM 1412 Magnetic Character Reader
IBM 1419 Magnetic Character Reader

Optical

IBM 1231 Optical Mark Page Reader Model N1
IBM 1285 Optical Reader
IBM 1287 Optical Reader Models 1 and 2
IBM 1418 Optical Character Reader Models 1-3
IBM 1428 Alphameric Optical Reader Models 1-3

Visual Input/Output

The IBM 2250 Display Unit (Figures 10 and 11) provides high-speed visual communication between the System/360 and its user. Tables, graphs, charts and alphameric data are displayed within the 12-inch square central area on the face of a 21-inch cathode ray tube. Keyboards and a light pen supply the means for entry and change of computer information.

The IBM 2260 Display Station is a lower-speed, table-top device for displaying computer output in alphameric form, either locally or at installations up to thousands of miles distant from the processing unit. Data such as insurance records or airline reservations are presented on a 4- by 9-inch area on the cathode ray tube. With the attachment of a keyboard (Figure 14), messages can be keyed in at any location, displayed, and sent to main storage.

IBM 2250 Display Unit Models 1 and 3; IBM 2840 Display Control Model 2

The general use of the IBM 2250 Display Unit is for the on-line displaying, updating, and manipulating of drawings and alphameric data. It also has usage as a system operator console, in which it substantially reduces the time needed for transferring messages between the operator and the system.

Specific applications are innumerable: the display of readings from process control indicators, along with computer messages for operator guidance of the process; the display of engineering drawings, with the user sketching changes on the drawings and requesting the results of the changes; or the display of intermediate and/or final results of scientific calculations, in the form of curves, plotted points, bar graphs, or symbols.

The display area (Figure 12) contains over 1,000,000 display points that can be individually addressed by X and Y coordinates. The CRT beam is deflected to each point on the screen that is addressed by the program, intensifying that point only if so directed by the program. If the beam motion is only horizontal, vertical, or at 45 degrees, the path traversed by the beam on its way between one end point and the other can also be intensified; by this means, continuous horizontal and vertical lines of unlimited length or 45 degree lines of limited length are made visible. Lines can be displayed at any other angle as a series of dots. A further ability to display continuous straight lines of unlimited length

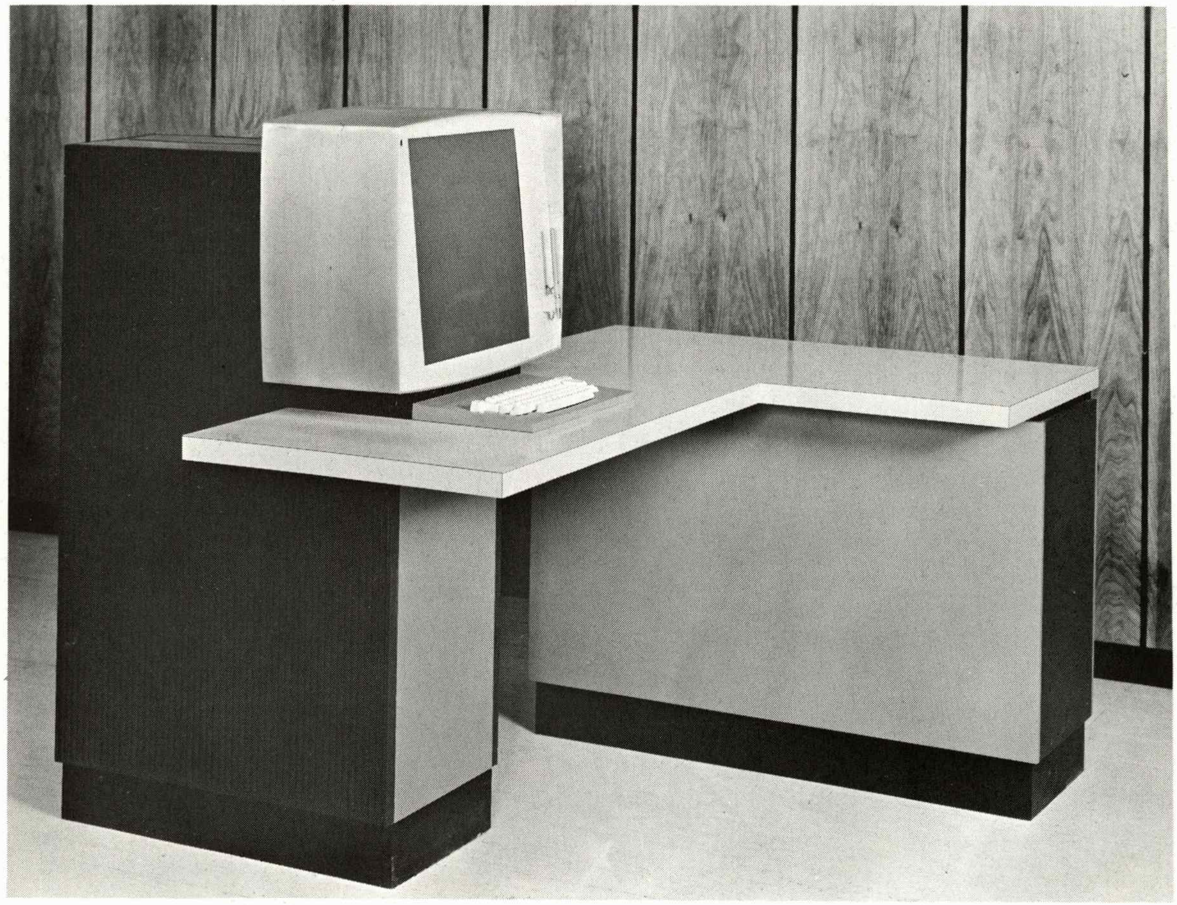


Figure 10. IBM 2250 Display Unit Model 1

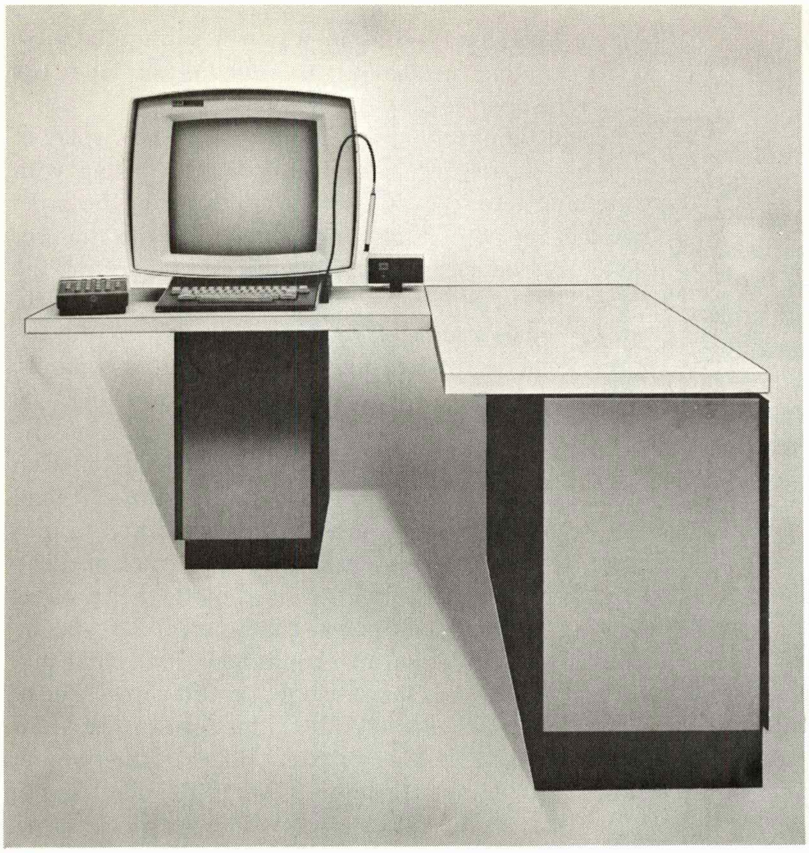


Figure 11. IBM 2250 Display Unit Model 3

at any angle is detailed under "Absolute Vectors and Control."

The 2250 is available in two models (Figures 10 and 11), which differ in the location of the control unit, logical power in the buffer, and in the features that are standard. Model 1 has a self-contained control unit; Model 3 units are linked to the channel and processing unit through an IBM 2840 Display Control Model 2.

Multiple Display

A 2840-2 can control as many as four Model 3 display units, each able to operate as far as 2,000 feet away from the 2840. The first two display units are attachable to a standard 2840; for the second two, a display multiplexer feature must be installed on the 2840. As many as eight control units can be attached to a channel.

Different images or the same image can be displayed on all display units simultaneously. The buffer storage in the 2840 is shared by all the 2250's attached, with portions being assigned to individual units by the program.

Light pen tracking can be performed simultaneously by the operator of each 2250 Model 3 without interference to the system.

Special Features

Light Pen (*Standard Feature for Model 3*) is a pen-like device that enables the operator to identify to the program a particular point, line, or character in the displayed image. The operator moves the pen point to the part of the image he wants to identify; the photodetector associated with the pen, sensing light at that point, generates a signal for the program. The light pen can be used alone or in conjunction with a keyboard to rearrange or delete information, or to add lines from a base point already lighted by the CRT beam.

An "electronic" light pen can be provided alone for the Model 1. Alternatively, a "fiber optics" light pen is provided with the graphic design feature for the Model 1; it is a standard feature of the Model 3.

Programmed Function Keyboard is a 32-key general-purpose keyboard, the keys of which are basically unidentified; with their functions defined by application-oriented interpretation programs. Each key starts a subroutine associated with a particular program. For example, the subroutine might direct the CPU to enlarge, reduce, or delete the image displayed.

Alphameric Keyboard is a typewriter keyboard that permits the user to enter messages consisting of letters, numbers, and other symbols into computer storage. As the message is composed, it is displayed on the screen

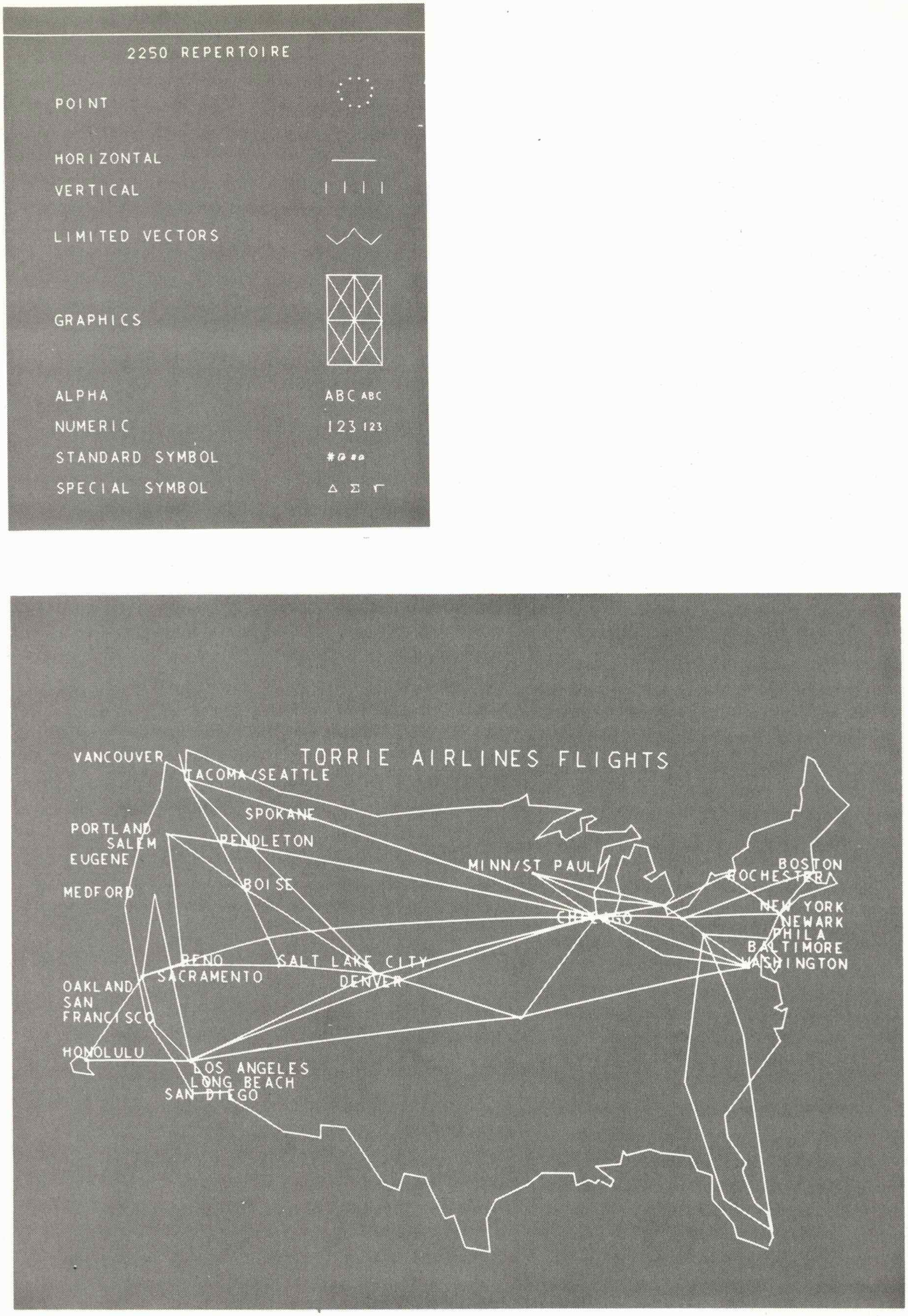


Figure 12. IBM 2250 Screen Contents. A Display Including Absolute Vector Graphics, Point Plotting, and Both Sizes of Alpha Characters

for verification or editing before it is transferred to main storage. This keyboard also controls the screen location of a movable dash symbol (cursor) that glows beneath the position at which the next character from the keyboard will be displayed.

Buffer (*Standard Feature for Model 3*) provides the Model 1 display unit with a choice of 4,096 or 8,192 bytes of internal storage. The 2840-2 provides, as a standard feature, 32,768 bytes of storage that are program-assignable to the attached Model 3 display units.

To maintain a display of information on the screen without a noticeable flicker, the display must be regenerated about 40 times per second (the maximum rate actually used). For an unbuffered display, regeneration would have to be performed by the computer. To free main storage and the channel for other functions and to allow the display unit to operate concurrently with the computer, the buffer is used to regenerate the display; the data that define the image are transferred from main storage to the buffer only once. Also, the buffer is used for assembling and editing of messages before they are transferred to main storage.

Transfers between main storage and buffer are at the rate of 4.2 microseconds per byte for Model 1, and at an effective rate of 2 microseconds per byte for the 2840 used with Model 3's. Thus, the buffer can accept data from the CPU at the rate of 238,000 bytes per second for Model 1, or 500,000 bytes per second for the 2840. (The 32K buffer in the 2840 can be completely rewritten in less than a tenth of a second.) In communication between the 2840 and Model 3's, the buffer is accessed at only 1 microsecond per byte. Points can be displayed as fast as 16.8 microseconds per point.

Character Generator (*Standard Feature for Model 3*) translates a byte specifying an alphameric character into the analog signals necessary to trace the character on the face of the tube; relieves the program of the task of individually addressing a series of dots or lines that are synthesized on the display into the specified character. Instead, a single data byte from the CPU specifies one of the characters available with the charactor generator. Two character sizes are program selectable: basic size or 1½ times basic size. The screen has room for 3,848 basic-size characters (on 52 lines of 74 characters each) or 1,715 1½-size characters (on 35 lines of 49 characters each). The latter case is equivalent to about two thirds of a column on this page. The average time required to display alphameric data with this feature is 15 microseconds per character for the basic size or 17 microseconds for the 1½ size. The number of characters per second depends on the program. Characters can be displayed from the buffer at the rate of 60,000 per second.

Operator Control Panel (*For Model 1 Only*) duplicates the facilities in the operator control section of the system control panel on the processing units of System/360 Models 50-91. One or two operator control panels can be installed on the 2250 Model 1. Two panels enable the 2250 to control either of two systems (Models 50-91) in a multisystem.

Absolute Vectors and Control (*Standard Feature for Model 3*) enables the 2250 Model 1 to trace continuous straight lines at any angular position within the 12-inch by 12-inch display area on the CRT. A line (vector) can be drawn between any two addressable points. More than a million points are addressable: 1,024 on the X axis by 1,024 on the Y axis. XY coordinates are programmed to specify the point to which each vector is drawn.

Graphic Design (*Standard Feature for Model 3*) provides (1) incremental vectors and point plotting, (2) a special fiber optics light pen, (3) light pen control orders. For the Model 1, the absolute vectors and control feature is a prerequisite.

In the fiber optics light pen (Figure 13), light is transmitted from the screen back to a sensing device in the console through a flexible connection made of glass fibers. Also, instead of being used in conjunction with a foot switch, this new light pen has a tip switch that is operated by depressing the pen tip on the screen.

Through programming, the graphic design feature enables the user to locate the light pen on a blank part of the screen, or to track the pen's path, with a minimum of CPU interruption. Locating the pen (pen search) is done by momentarily sweeping the screen with characters or short vectors and saving the XY location of the one character or vector that activated the light pen. Pen search is a good way to initiate pen tracking.

In pen tracking, a small cross or box is displayed under the pen and moves with the pen; the cross or box supplies the light to keep the pen activated, and the program updates the symbol location. In one tracking technique, a light trail can be made to follow the pen much as an ink trail follows an ordinary pen. Alternatively, a single vector can be displayed from each starting point of tracking to the pen, for an effect called rubber banding. The incremental vectors and light pen control orders provided by the graphic design feature enable pen tracking to be directed by the CPU and buffer programs. (With the 2250 Model 3, only the buffer program is needed.) With the user's program as aided by this feature, there is no need for the CPU to compute every point on the tracking symbol as it is continually relocated, because resetting the starting point of the first vector moves the entire symbol to the new location.

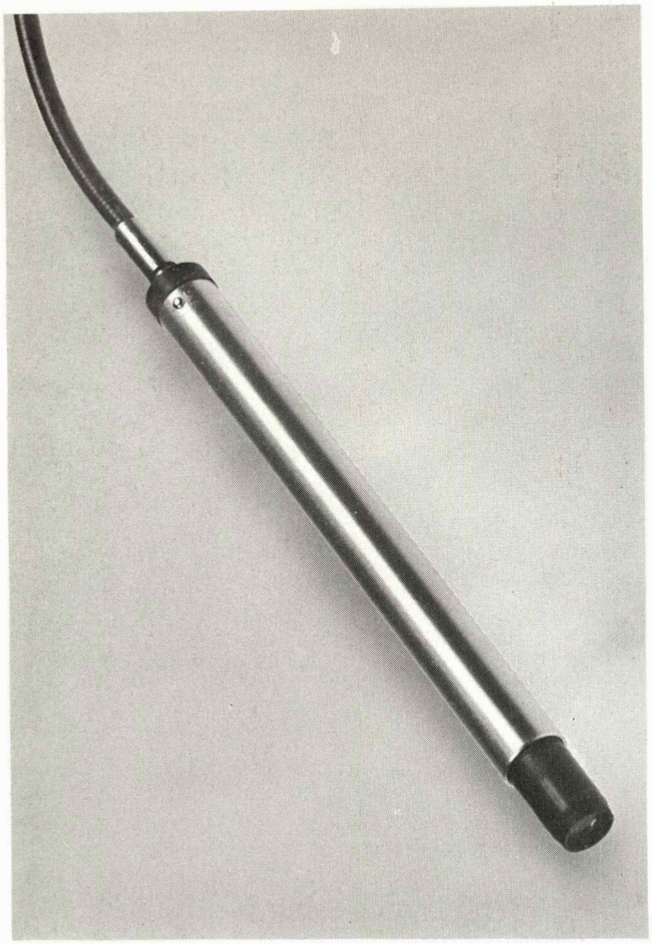


Figure 13. Fiber Optics Light Pen

With the incremental vectors, a line is drawn to any point on the screen, up to 0.74 inch from the absolute X and Y values of the starting point, by specification of increments along the X and Y axes rather than by absolute specification of the destination point. The same distances and method of specification apply to incremental point plotting. With a series of changes in the starting point and by use of an appropriate subroutine within the buffer, an image such as a resistor or a rivet head can be made to appear at many places on the screen simultaneously.

Features of 2840 Model 2

The only special feature for the 2840 control is the display multiplexer, which permits the attachment of two additional 2250 Model 3's for a total of four. No more than one display multiplexer can be installed per 2840 Model 2.

Many functions can be performed totally within the standard 32K buffer, thereby eliminating many interruptions and programming task-switching operations in the CPU.

Other standard features of the 2840-2 are the character generator, absolute vectors, incremental vectors, and light pen control orders that are provided with special features for the Model 1 display unit. The subroutine capability within the buffer permits the displaying of an image such as a resistor at many places on the screen even though the control orders appear only once in the buffer program.

Unique Equipment

The System/360 Model 91 has a display console that is, essentially, a 2250 Model 1 equipped with:

One operator control panel
Alphameric keyboard
Character generator
4,096-byte buffer

The display console is a standard feature integrated with the system control panel. When switched to a maintenance function, communication is from the system control panel to the display console; when switched to the channel (normal connection), the display console is used for two-way communication with the CPU.

The following may be added to the display console as special features:

Light pen
Absolute vectors and control
Programmed function keyboard
Second operator control panel
Graphic design

The existence of this display console for the Model 91 does not preclude the attachment of 2250's in the conventional manner.

On the Model 67, either the 2250 Model 1 or the 2840 may be switched between two channels.

IBM 2814 Switching Unit Models 1-3

An IBM 2814 Switching Unit may be installed, on Model 67 only, to provide program-controlled switching of a display control unit between two channels:

2814 Model 1 is used to switch a 2250 Model 1.
2814 Model 2 is used to switch a 2840 Model 2.
2814 Model 3 is used to switch a 2848, which is the control unit for IBM 2260 Display Stations.

IBM 2260 Display Station;
IBM 2848 Display Control Models 1-3

The IBM 2260 Display Station (Figure 14) is an efficient and compact cathode ray tube unit used for the local or remote display, in alphameric form, of data from the processing unit. The 2260 is controlled and buffered by its IBM 2848 Display Control.

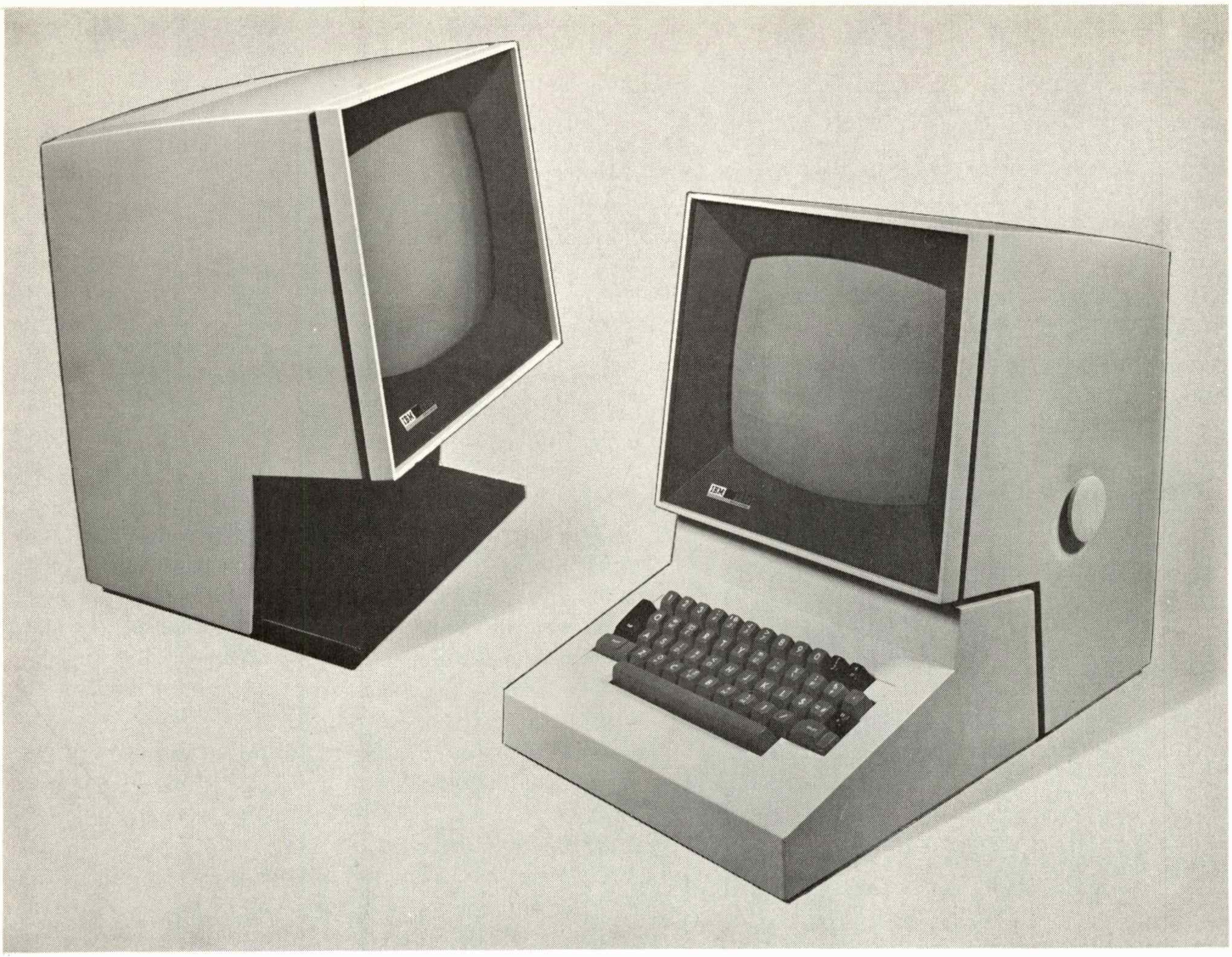


Figure 14. IBM 2260 Display Station, without and with Alphameric Keyboard

Numerous 2260's can be operated by a single 2848 which (for local operations) is attached to a system channel directly. The 2260's may be up to 2,000 feet distant from the control unit; such operations are still classed as local. For more remote operations, the 2848 is attached to the channel via the IBM 2701 Data Adapter Unit; the main link between the CPU and the remote display equipment is established by telephone lines and a pair of data subsets. That is, the connection between the CPU and 2260 is via (respectively) the channel, the 2701, the local subset, the telephone lines, the remote subset, and finally the 2848 control unit.

All 2260's serving as output for the CPU may present the same alphameric display at the same time, or each 2260 can present a completely different display while all are in concurrent operation.

The maximum data rate when the 2848 is attached directly to a channel is 2,560 bytes (= characters) per second; when it is attached through a 2701, bytes are converted to USASCII-7 code for long-distance transmission and the maximum data rate is either 120 bytes/1,200 bits per second or 240 bytes/2,400 bits per second. (The 1,200 or 2,400-bit figures include the start, stop, and check bits transmitted with each seven-bit character.) Each character requires one byte or USASCII code point; packed decimal mode cannot be used.

Either a numeric or an alphameric keyboard can be installed on any 2260. With the keyboard, the user can enter numeric or alphameric messages into CPU storage. The message is displayed on the screen for verification or editing before it is transferred from the display control to main storage. The operator may request text, insert or delete lines in it, and otherwise edit the text at the keyboard, and return the edited text to storage. These facilities are such that a client's account can be displayed, updated, and stored while he is on the telephone.

The number of 2260's that can be controlled by each 2848, and the capacity of the display within the 4- by 9-inch display areas, is determined by the 2848 model and special features permitting expansion:

2848 MODEL	DISPLAY CAPACITY	MAX NO. OF 2260's PER 2848 WITHOUT EXPANSION	MAX NO. OF 2260's PER 2848 WITH EXPANSION
1	240 characters (40 in each of 6 lines)	4	24
2	480 characters (40 in each of 12 lines)	2	16
3	960 characters (80 in each of 12 lines)	2	8

Appropriately, the buffer in the 2848 can hold up to 240, 480, or 960 bytes. In addition to buffering the input or output, it serves to regenerate the display 30 times per second for maintenance of its visibility.

As implied by the preceding table, expansion unit special features are required when more 2260's are to be attached to a control unit than are provided for by the basic machine. In actuality, all 2260's are attached to the 2848 through display adapters, with each display adapter providing the control for two 2260's. The basic 2848 provides for the attachment, without expansion unit features, of one display adapter for 2848 Models 2 or 3, or two display adapters for Model 1. An expansion unit enables the attachment of additional display adapters.

A line addressing feature is available for the 2848 to permit the writing of data from the CPU to be started at the beginning of any display line selected by the program.

The 2848 contains the character generator that is necessary to convert data from the channel or signals from the keyboard into video data. Sixty-four characters may be displayed: the 26 upper-case letters, the 10 decimal digits, and 25 special characters.

The parity error symbol, a solid rectangle, appears on the display as a nonvalid character signal to the operator.

Either a destructive or nondestructive cursor (the latter a special feature) may be specified by the user. The destructive cursor, a short horizontal line, appears in the position wherein the next character will be displayed; the nondestructive cursor, a short vertical line, appears below and to the left of that position. If the destructive cursor is backspaced or otherwise moved over displayed characters, it obliterates them from the display and from the buffer. The nondestructive cursor feature and its adapter allow the operator to move the cursor anywhere on the display without changing the displayed information.

The start manual input symbol (▶) is used to indicate the start of input data, all or part of which may be intended for eventual transmission to the CPU.

On the Model 67, the 2848 may be switched between two channels. (See "IBM 2814 Switching Unit Models 1-3.")

Printout on IBM 1053 Printer Model 4

The contents of the 2848's buffer storage, or information from the channel, can be directed for printout to an IBM 1053 Printer Model 4 attached to the 2848. One printer can be attached to each 2848 in the system. The attachment requires a 1053 adapter on the 2848; when the 2848 is a Model 1 or 2, an expansion unit feature is also required. The buffer for a 1053 has a capacity of 1,223 bytes.

The 1053 is further described under "Printers."

Manual Controls

IBM 1052 Printer-Keyboard Models 3, 5, 6, 7, and 8

The IBM 1052 Printer-Keyboard (Figure 15) can be attached to the system for communication between the operator and the system: for example, such operator-program exchanges as program checking or correcting and job logging. Facilities are provided for interrupting the processing unit and for signaling the end of the operator's transmission.

The typewriter-style keyboard and the printing function can be used independently: the keyboard for system input, and the printer for computer output. The 1052 has a stationary carriage and a spherical, interchangeable printing element.

In Model 30, the 1052 must be connected via an IBM 1051 Control Unit. The 1052 may be operated as the only device connected to the 1051, or other local I/O devices from an IBM 1050 Data Communications System may also be connected to the 1051. Remote 1050 systems can also be connected to the 1051, but may be operated only off-line.

Five models of the 1052 can be attached to the System/360 and operated under the control of its program: Models 3, 5, 6, 7, and 8. Models 7 and 8 are as shown in Figure 15. The appearance of Models 3, 5, and 6 differs in small details, in keeping with the presence of tabulation, backspacing, single/double indexing, paper releasing, ribbon shifting, and line feeding functions in those models. (A program with commands for such functions also runs on Models 7 and 8, but the functions are not performed.)

The nominal speed of Models 3, 5, 6, and 8 is 14.8 characters per second; of Model 7, 15.5 characters per second. For Models 3, 5, and 6, line spacing (either 6 or 8 to the inch), character spacing (either 10 or 12 to the inch), and the font of each printing sphere are all as specified by the customer; Models 7 and 8 differ in that line spacing is set at 6 lines per inch and character spacing is set at 10 characters per inch. The maximum line length for Models 3, 5, and 6 is 13 inches, for up to 130 or 156 characters at, respectively, 10 or 12 per inch; for Models 7 and 8, it is 12.5 inches, for up to 125 characters.

The five models differ also in their electrical connections, and these correspond to the four different ways in which the 1052 may be connected:

Model 3 is attached to a System/360 Model 30 via the 1051 Model 1. (This is the only configuration that permits the connection of remote 1050 systems.)

Model 5 is attached to a System/360 Model 30 via the 1051 Model N1 when other local I/O devices of a 1050 system are to be attached. The Model 5 provides the additional switches needed.

Model 6 or 8 is attached to a System/360 Model 30 via the 1051 Model N1 when *no* other devices of a 1050 system are to be attached (see Figure 43).

Model 7 is attached to a System/360 Model 40-91 via a 1052 adapter which can be installed in two places: within the processing unit of Models 40-67 (Figure 5) or within the IBM 2150 Console available for Models 50-91 (Figure 16). Models 50-67 can use either or both methods of attachment.

It can be seen that only a Model 7 is attachable without a 1051 control unit or to a system other than Model 30. Attachment of a 1052 via the 1051 does not require a control-unit position of a channel. The Model 7 requires a control-unit position on one of the channels noted in Figure 52.

On Model 44, this machine is made a standard feature of the CPU; accordingly, it has no separate ma-

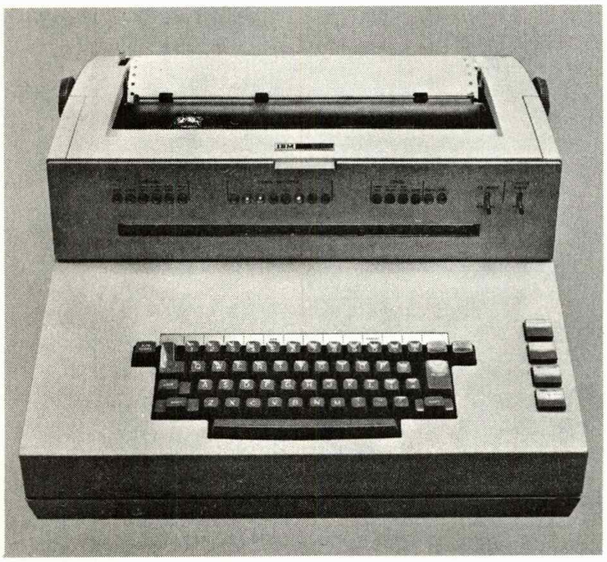


Figure 15. IBM 1052 Printer-Keyboard

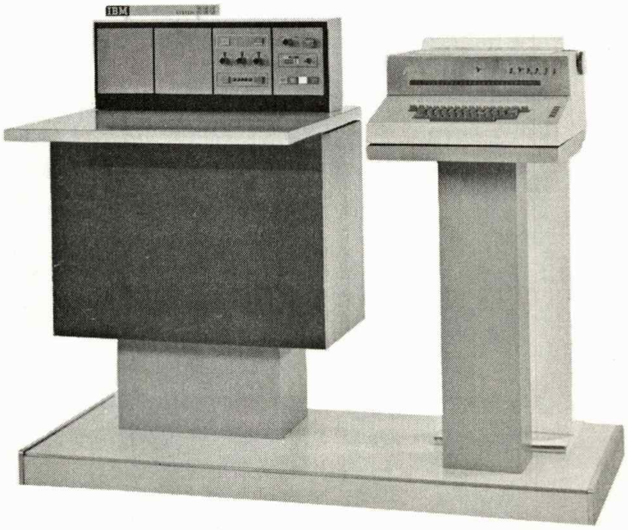


Figure 16. IBM 2150 Console and 1052 Printer-Keyboard

chine number of 1052 Model 7, but is simply the "console printer-keyboard"—exactly equivalent to the Model 7.

The 1052 Models 7 and 8 are specifically improved for system console use, with greatly increased simplicity and reliability; the Model 8 improves the Model 6, and the present Model 7 improves the earlier Model 7. Only those standard features that are useful or necessary in a system environment are available. A pin-fed paper with 13⅛-inch width from hole to hole must be used, and the left and right margin stops are fixed.

A number of special features are available for the 1052 Models 3, 5, and 6, including an accelerated carrier return for speeding the carrier return time to about half that of a standard 1052, and a forms feed that provides control over the vertical movement of continuous paper forms.

For an installed Model 6 and its associated 1051 Model N1, the user may specify a functional compatibility with Model 8. In that case, the accelerated carrier return feature, if installed on the Model 6, can be continued; and if the Model 6 was installed with 8 lines per inch and/or 12 characters per inch spacing, these functional differences will also remain.

An IBM 1053 Printer Model 1 can be installed in place of a 1052 Model 6/8 or together with (or in place of) a 1052 Model 5. The 1053 (Figure 37) is similar to the 1052 but has no keyboard. It is further described under "Printers."

IBM 1051 Control Unit Models 1 and N1

The IBM 1051 Control Unit Model N1 provides control circuitry and attachment facilities for (1) a 1052 Model 6/8 or 1053 Model 1 alone, or (2) a 1052 Model 5 and/or 1053 Model 1 and other local devices of a 1050 system. Including the 1052, the maximum local configuration is four devices, with alternatives in three:

1. One 1053-1 Printer
2. One 1052-5 Printer Keyboard or a second 1053-1 Printer
3. One of the following:
   a. 1054 Paper Tape Reader
   b. 1056 Card Reader
   c. 1092 Programmed Keyboard
   d. 1093 Programmed Keyboard
   e. tandem 1092/1093 Programmed Keyboards
4. One 1055 Paper Tape Punch or 1057 Card Punch

The optional home component recognition feature permits any of the locally attached 1050 devices to be turned on and off under the control of characters in the data field rather than by keys at the 1052 keyboard.

Model 1 of the 1051 control unit attaches a 1052 Model 3 and provides for the same local 1050 devices as Model N1, and can also attach remote 1050 systems via appropriate data sets and communication lines.

In 1050 language, local operations are termed "home loop." All operations of the local 1050 devices are therefore in home loop; and may be either on-line or off-line. Line loop (communication with remote 1050 systems) is strictly off-line.

The 1051 Model 1 requires the master station feature to communicate with the remote 1050 systems and can—if an adequate configuration of local 1050 devices are attached to the 1051—poll, address, and communicate off-line with up to 25 such 1050 systems. This operation differs in no way from that of a 1050 system which has no connection to the System/360.

IBM 2150 Console

The IBM 2150 Console provides the IBM System/360 Models 50-91 with a duplication of the operators' controls at a station removed from the processing unit (Figures 6 and 16). A location is provided on the free-standing 2150 for mounting one or two operator control panels. Two panels enable one 2150 to control either of two systems in a multisystem.

The 2150 Console includes an operator's chair, a program-controlled audible alarm, and an adapter for the IBM 1052 Printer-Keyboard Model 7. The 1052 communicates with only the processing unit to which the 2150 Console is attached (via a channel).

Tapes

IBM 2401 Magnetic Tape Unit Models 1-6; IBM 2803 Tape Control Models 1 and 2; IBM 2804 Tape Control Models 1 and 2

The IBM 2401 Magnetic Tape Unit (Figures 17 and 18) reads or writes nine tracks across half-inch wide, IBM DYNEXCEL heavy-duty magnetic tape or Mylar* tape at a density of 800 or 1,600 bytes per inch (bpi). (The use of Mylar tape is not recommended for 1,600-bpi operation.) Each byte contains one letter or special character, or two four-bit decimal digits, or one decimal digit and a sign, or eight binary bits, etc., and a ninth bit used for parity checking.

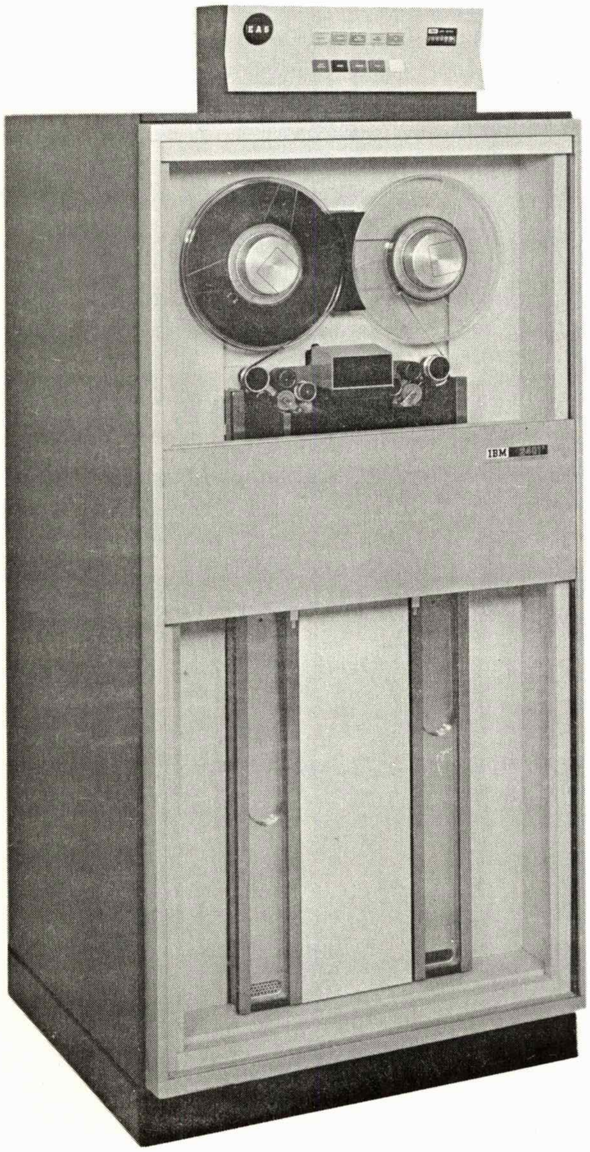


Figure 17. IBM 2401 Magnetic Tape Unit (Using Transparent Reels)

The 2401 is available in six models. The model numbers designate the drive speed in bytes per second (bps), which is directly related to two factors: tape speed in inches per second (ips) and data density in bytes per inch of tape (bpi).

Model 1	30,000 bps at 37.5 ips at 800 bpi
Model 2	60,000 bps at 75 ips at 800 bpi
Model 3	90,000 bps at 112.5 ips at 800 bpi
Model 4	60,000 bps at 37.5 ips at 1,600 bpi
Model 5	120,000 bps at 75 ips at 1,600 bpi
Model 6	180,000 bps at 112.5 ips at 1,600 bpi

Models 4-6 use the technique of "phase encoding" for its advantages of high speed and automatic single-track in-flight error correction.

Further characteristics and comparisons of the tape drives are shown in Figures 19 and 20.

Tape Controls

The IBM 2803 and 2804 Tape Controls are differentiated by the ability to control drives in the reading and writing on one channel or two:

2803	Reading or writing on one channel
2804	Simultaneous reading on one channel and writing on another

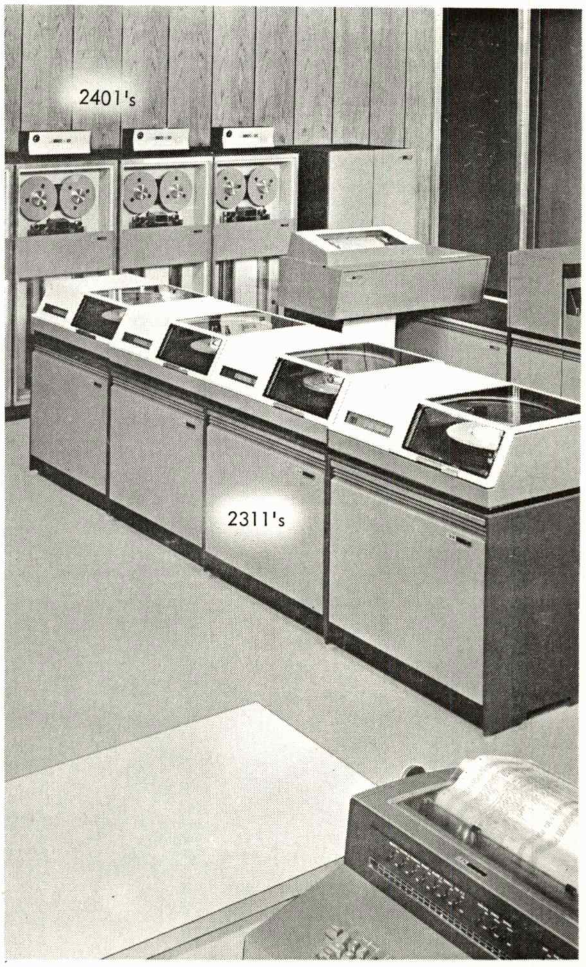


Figure 18. IBM 2401 Magnetic Tape Unit and 2311 Disk Storage Drive

---

*Trademark of E. I. du Pont de Nemours & Co. (Inc.)

	IBM 2415		IBM 2401					
Characteristic	Models 1-3	Models 4-6	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Data Rate (bytes per second)	15,000	30,000	30,000	60,000	90,000	60,000	120,000	180,000
Tape Speed (inches per second)	18.75	18.75	37.5	75	112.5	37.5	75	112.5
Standard Density (bytes per inch)	800	1600	800	800	800	1600	1600	1600
Nominal Interblock Gap (inches)	.6	.6	.6	.6	.6	.6	.6	.6
Nominal Interblock Gap Time (milliseconds)	32	32	16	8	5.3	16	8	5.3
Rewind Time (minutes) including reloading	4	4	3	1.4	1	3	1.4	1
Rewind and Unload Time (minutes)	4	4	2.2	1.5	1.1	2.2	1.5	1.1
Tape Width (inches)	.5	.5	.5	.5	.5	.5	.5	.5
Standard Number of Tracks	7 or 9	9	7 or 9	7 or 9	7 or 9	9	9	9

Figure 19. Characteristics of IBM 2401 and 2415 Magnetic Tape Drives

The 2803 and 2804 control as many as eight drives and are in two models. Model 1 is for control of the 800-bpi tape drives in 2401 Models 1-3. Model 2 is primarily for control of the 1,600-bpi drives in 2401 Models 4-6, but may also control 800-bpi tape drives if either the nine-track compatibility feature or the seven- and nine-track compatibility feature is installed. (Also, each 2401 Model 1-3 attached to Model 2 of the 2803 or 2804 must have the mode compatibility feature.)

The 2804 attaches to two channels in a manner that permits a read-type operation on one tape drive to be overlapped with a simultaneous write, write tape mark, or erase tape operation on another drive. Each 2401 attached to one of these simultaneous controls must have the simultaneous read-while-write feature. All Models 4-6 of such 2401's are controlled by a 2804 Model 2.

Controls attach to a selector or multiplexer channel and operate in the burst mode. (With System/360 Models 30 and 40, 180,000 byte-per-second drives must be operated on a selector channel.) A 2803 requires a control-unit position on the channel; a 2804 requires one control-unit position on each of two channels.

Sixteen-Drive Addressing

When the optional 16-drive addressing feature is installed on a 2803, that 2803 is enabled to address as many as sixteen 2401 tape drives, in a pool that is under switching control by IBM 2816 Switching Units Model 1. (See "IBM 2816 Switching Unit Models 1 and 2.") This feature is not needed unless a 2803 must have the capability of addressing more than eight tape drives.

On the Model 67, a two-channel switch feature is available to switch the 2803 Model 1 between two channels.

Seven-Track Compatibility

An optional seven-track compatibility feature enables a 2401 Model 1-3 to write or read seven-track tape at 200, 556, or 800 characters per inch; this provides tape compatibiilty with devices such as IBM 729 and IBM 7330 Magnetic Tape Units. The seven-track compatibility feature can be installed on any tape control and is required if any attached tape drive of Models 1-3 has the seven-track head. As part of the seven-track compatibility feature, a code translator feature is included to translate the BCD interchange code to the System/360 code (EBCDIC).

Installations with seven-track compatibility may also have, on the tape control, an optional data conversion feature that converts three bytes to four groups of six bits or vice versa, for processing data with maximum packing efficiency. This feature cannot be used when seven-track tape is read in the backward direction.

Nine-Track Compatibility

In keeping with the flexibility that provides for any practical variation in requirements, an optional nine-track compatibility feature is available for Model 2 of the 2803 and 2804 to allow the reading and writing of nine-track tape at 800 bpi as well as 1,600 bpi. This feature is required when:

1. Any attached tape drive of Models 1-3 has a nine-track head.
2. Any attached tape drive of Models 4-6 has the dual-density feature.

The dual-density feature enables the Models 4-6 drives to operate with nine-track tape at 800 bpi in addition to 1,600 bpi. (As stated previously, each Model 1-3 drive attached to the 2803/2804 Model 2 must also have the mode compatibility feature.)

Seven- and Nine-Track Compatability

The nine-track and seven-track compatibility features are mutually exclusive on the same tape control. However, instead of either feature, an optional seven- and nine-track compatibility feature can be installed on Model 2 of the 2803 or 2804 to provide all the advantages of both features.

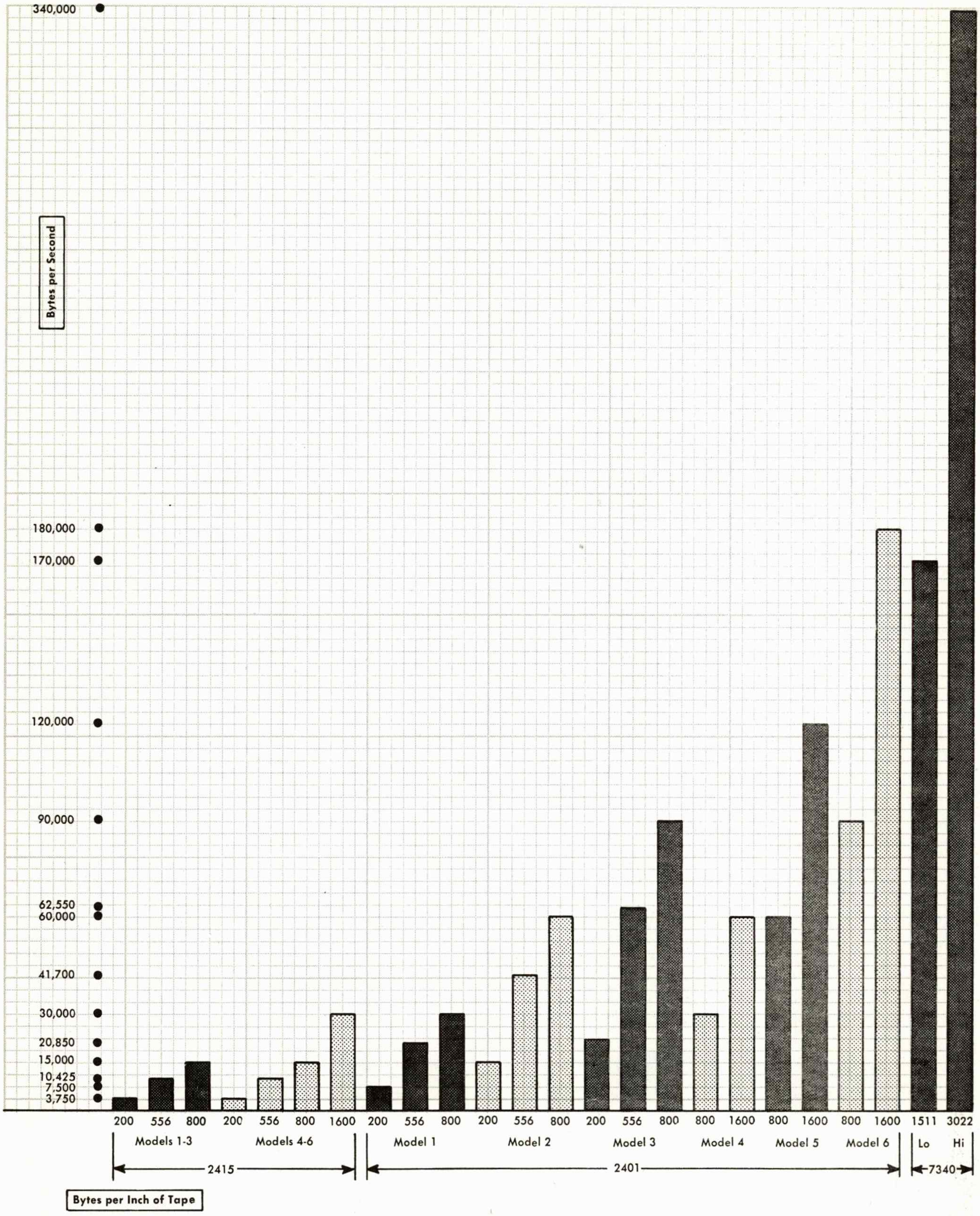


Figure 20. Comparative Data Rates of Magnetic Tape I/O Used with System/360

Standard Features

Error correction is a standard feature of these magnetic tape units; for the 800-bpi, nine-track format, it provides error correction on a reread of a record containing one or more errors in a single track. With a simple programming aid, the reread corrects almost every single-track error on the nine-track tape. For the 1,600-bpi, nine-track format, single-track errors are corrected in flight.

Other standard features include:

1. A powered access window that opens and closes with the touch of a button, and opens automatically, when the rewind unload order has been executed, to signal the operator that another reel is required.
2. Read backward, which enables any nine- or seven-track tape written by a 2401 to be read by a 2401 in either the forward or the backward direction, thus eliminating many tape rewinding operations and speeding the access to tape records.

IBM 2415 Magnetic Tape Unit and Control Models 1-6

The IBM 2415 Magnetic Tape Unit and Control (Figure 21) provides a tape service similar to and compatible with the 2401, but at a downward extension of the speed range and with any given tape control limited to governing the group of two, four, or six drives with which the control is housed. In each 2415 attached to a channel, one drive may be operated at a time. Simultaneous read/write is not provided.

With the 2415, model numbers designate not only the drive speed but also the number of tape drives that are in the same housing as the control. The drive speed depends on the data density—the tape speed being a constant 18.75 inches per second for all models —and the drives within the housing all operate independently.

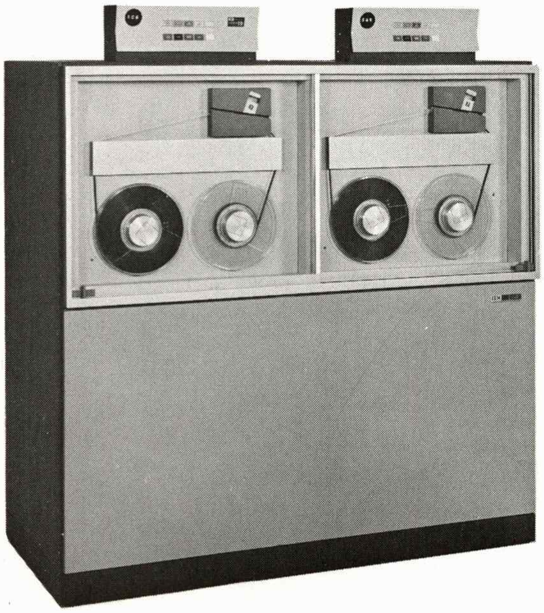


Figure 21. IBM 2415 Magnetic Tape Unit and Control Model 1

Model 1	two drives, each 15,000 bps at 800 bpi
Model 2	four drives, each 15,000 bps at 800 bpi
Model 3	six drives, each 15,000 bps at 800 bpi
Model 4	two drives, each 30,000 bps at 1,600 bpi
Model 5	four drives, each 30,000 bps at 1,600 bpi
Model 6	six drives, each 30,000 bps at 1,600 bpi

Basic characteristics and comparisons of the 2415 drives are included in Figures 20 and 21. As with the 2401, Models 4-6 use the phase encoding technique. Only the nine-track compatibility feature or the seven-and-nine-track compatibility feature is required to enable Models 4-6 to read and write at 15,000 bps and 800 bpi in addition to their higher basic speed and data density.

The 16-drive addressing feature is not provided, and 2415's cannot be switched between tape controls.

The 2415 has a manually-operated, sliding access window rather than a powered access window.

Error correction for the 2415 is the same as for the 2401, with one exception: in the 800-bpi, nine-track format, 2415's are not capable of correcting errors during read operations. All errors are detected, however, and conventional error recovery routines apply.

The seven-track compatibility feature is available for all 2415 models, and either it or the seven-and-nine-track feature is required when any drive in the 2415 unit has a seven-track head.

The nine-track and seven- and nine-track compatibility features available for the 2415 Models 4-6 operate as described for the 2401, with the same provisions and limitations, except: one feature or the other is not required if a drive in the 2415 has a nine-track head, but only when the drive must be able to read and write at dual density. The so-called dual-density feature is not required for the 2415 drives. The mode compatibility feature is never required for the 2415.

All other 2415 features, including the data conversion feature and read backward, operate the same way as described for the 2401.

IBM 7340 Hypertape Drive Model 3; IBM 2802 Hypertape Control

The IBM 7340 Hypertape Drive Model 3 (Figure 5) and its IBM 2802 Hypertape Control provide the IBM System/360 with the highest performance magnetic tape input and output. Characteristics of the Hypertape drive are shown in Figures 20 and 22.

In the low-density mode, the Model 3 Hypertape drive can read tape written by Model 1 or 2 Hypertape, with character translation performed by the System/360 program.

Data Rate	
Low	170,000 bytes per second
High	340,000 bytes per second (Byte--eight binary bits, or two four-bit decimal digits, or one letter or a special character, or one sign and one decimal digit, etc.)
Recording Density Programmed	
Low	1511 bytes per inch
High	3022 bytes per inch
Tape Speed	
Read, Write, Read Backward	112.5 inches per second
Rewind	112.5 inches per sec for first 10 sec 225 inches per sec after first 10 sec
Rewind Time (approximate)	90 seconds for full reel
Nominal Interblock Gap	
For Low Recording Density	0.45 inch
For High Recording Density	0.38 inch
Nominal Read/Write Access Time	3.5 milliseconds
Tape Cartridge	
Tape Width	1 inch
Tape Length	1,800 feet
Automatic Cartridge Loader Optional Feature	
Change Cartridge Cycle	Less than 45 seconds from tape in columns to tape in columns.

Figure 22. Highlights of IBM 7340 Hypertape Drive Model 3

Extremely high reliability is provided by Hypertape's fluid starting/stopping and abrasion-free driving of tape, as well as by the 10-track recording method that uses two parity bits. The eight data bits are checked in two groups, with one parity bit per group. Some of the data bits are included in both groups; this simultaneous double- and cross-checking proves the proper identification of more questionable data bits within a byte than is possible with single parity checking. All read and write errors are detected, and, when reading, all single-track errors and 33 of the possible 45 double-track errors are corrected automatically.

Standard features include read backward, which eliminates many tape rewinding operations and speeds the access to tape records. Tape threading and unthreading is automatic. Also, it is unnecessary to rewind a reel of tape before unloading the cartridge in which it is contained.

Enclosing the tape for Hypertape drives in a cartridge eliminates virtually all tape contamination or damage owing to manual handling. A slide in the back of the cartridge, operated either manually or by the program, can prevent the drive from writing on a tape file that is to be protected.

A special feature, the automatic cartridge loader, can be mounted on top of the Hypertape drive. (This necessitates a relocation of the control panel; see Figure 23.) The automatic cartridge loader reduces the time spent on tape handling, automatically unloading a processed cartridge and loading the next cartridge in less than 45 seconds under the program control provided by "Change Cartridge" control orders. While the current cartridge is being processed, the operator inserts the next cartridge and removes any discharged cartridge.

The IBM 2802 Hypertape Control can control up to eight 7340-3 drives. It attaches to the selector or multiplexer channel if Hypertape operation is at the "low" data rate of 170,000 bps, or to a selector channel of appropriate data handling capacity if Hypertape operation is at the "high" data rate of 340,000 bps. (See Figure 52.) Hypertape operation at the low or high data rate is specified by the program.

When the optional 16-drive addressing feature is installed on a 2802, that 2802 is enabled to address as many as sixteen 7340-3 drives, in a pool that is under switching control by IBM 2816 Switching Units Model 2. (See the following paragraph.) This feature is not needed unless a 2802 must have the capability of addressing more than eight Hypertape drives.

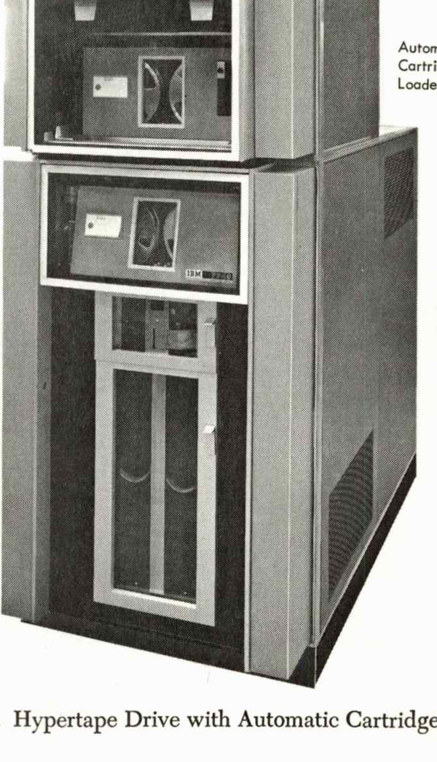


Figure 23. Hypertape Drive with Automatic Cartridge Loader

IBM 2816 Switching Unit Models 1 and 2

The 2816 (Figure 24) provides a means of assigning a tape drive to more than one tape control, thus allowing still more flexibility in tape configurations and the minimizing of such configurations: for instance, by allowing a control to have access to a drive that is attached to a different control. The 2816 introduces other advantages, including such unbalanced sort operations as three inputs to six outputs or vice versa, with the consequent minimum of time for manual mounting and demounting of reels.

With the 16-drive addressing feature installed on the appropriate tape controls and the use of two IBM 2816 Switching Units, a maximum of 16 tape drives may be controlled in common by a maximum of four tape controls. The minimum is control of four tape drives by two tape controls; any combination between the minimum and maximum is available. For more than eight drives, the second switching unit is required. The switching of tape drives on the 2816 is completely under program control, on a per-record basis.

Model 1 of the switching unit is used for switching tape drives in any mixture of 2401 Models 1-6; however, the 2816 requires a tape drive intermix feature for switching both 800-bpi and 1,600-bpi models.

The tape controls involved must be either 2803 Model 1 or 2803 Model 2; the 2816 cannot switch both Models 1 and 2 on the same system.

Model 2 of the switching unit is used for switching Hypertape.

If the 16-drive addressing feature is not installed on a tape or Hypertape control, it can control only the first eight drives in the tape or Hypertape pool.

IBM 2671 Paper Tape Reader; IBM 2822 Paper Tape Reader Control

The IBM 2671 Paper Tape Reader photo-electrically reads strips of 5-, 6-, 7-, or 8-channel paper tape at a rate of up to 1,000 characters per second. Tape width is 11/16 inch (for five-track telegraphic code), 7/8 inch (six- and seven-track codes), or 1 inch (eight-track codes). Tape code translation is under program control.

Various switches on the 2671 provide for operator convenience and program efficiency. Examples are end-of-record indications, parity checking (odd, even, or none), track suppression, and the transmission or non-transmission to the CPU of the indications of deleted positions on tape.

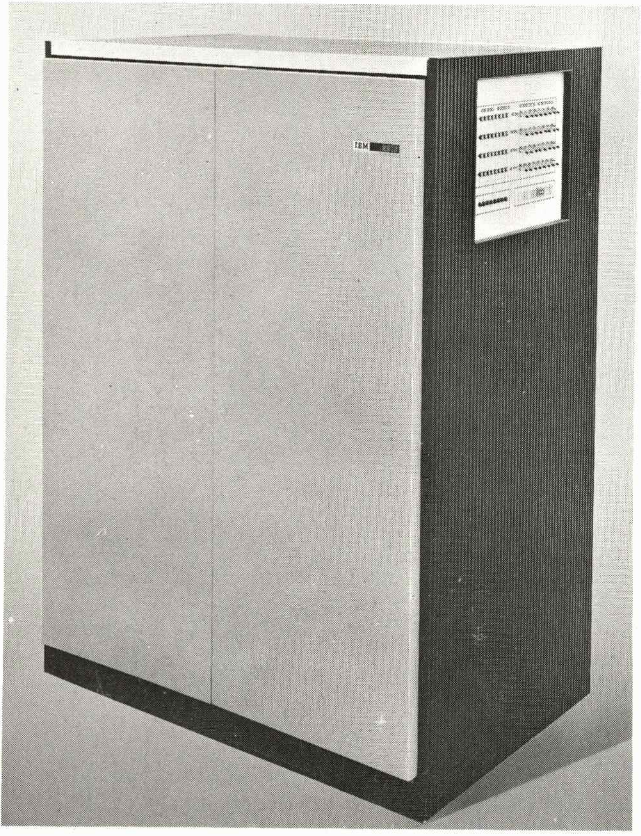


Figure 24. IBM 2816 Switching Unit

Figure 25. IBM 2671 Paper Tape Reader and 2822 Paper Tape Reader Control

The paper tape reader and its IBM 2822 Paper Tape Reader Control (Figure 25) are normally attached to the System/360 through the multiplexer channel but may be attached to a different channel on some models (Figure 52).

The basic 2671 reads strips of paper tape from 9 inches to 20 feet in length, including a 6-inch leader and 3-inch trailer. Spooling facilities are optional. With the supply option feature, 10½-inch reels of paper tape can be fed (from the outside of the reel). If the optional center roll feeding feature is added, tape may also be fed from the center of 10½-inch rolls. With the take-up option feature, the tape can be rewound on 10½-inch reels.

After acceleration time (about 8 milliseconds), the data rate reaches 1,000 characters per second for strips. With the spooling facilities, the data rate varies between 500 and 1,000 characters per second, depending on the length of a record.

This device is especially designed for data communications, source recording, for use in scientific data processing, and for data acquisition.

Direct Access

IBM 2302 Disk Storage Models 3 and 4

The IBM 2302 Disk Storage (Figure 26) can record and retrieve data either directly or sequentially; the direct capability permits immediate access to specific areas of information without the need to examine sequentially all the data in the file. The speed of the access enables the user to maintain up-to-the-second data files and make frequent retrievals of the data stored.

The 2302 Model 3 contains one disk storage module; the Model 4 contains two disk storage modules. Each module has two access mechanisms. Capacity per module is 112.79 million bytes (or 225.59 million packed decimal digits and signs). Eight accesses (four 2302-3's or two 2302-4's) may be connected to the System/360 through an IBM 2841 Storage Control, for on-line direct access to 451.19 million bytes (or 902.38 million packed decimal digits and signs) per 2841 attached.

A special feature on the control unit permits the number of attached 2302's, if not four, to be brought to the discrete maximum of four. Thus, if two 2302-4's are already attached, two additional 2302-4's, with eight access mechanisms, can be attached; or two additional 2302-3's, with four access mechanisms, can be attached.

The recording medium consists of thin, magnetically-coated metal disks that spin at about 1,800 revolutions per minute. Each disk surface is divided into 500 tracks; data and control information are recorded as magnetized spots on a track. Access (track seek) times are 50 milliseconds minimum, 180 milliseconds maximum, and 165 milliseconds average. Rotational delay averages 16.7 milliseconds. The transfer rate between the 2302 and the processing unit is 156 thousand bytes per second.

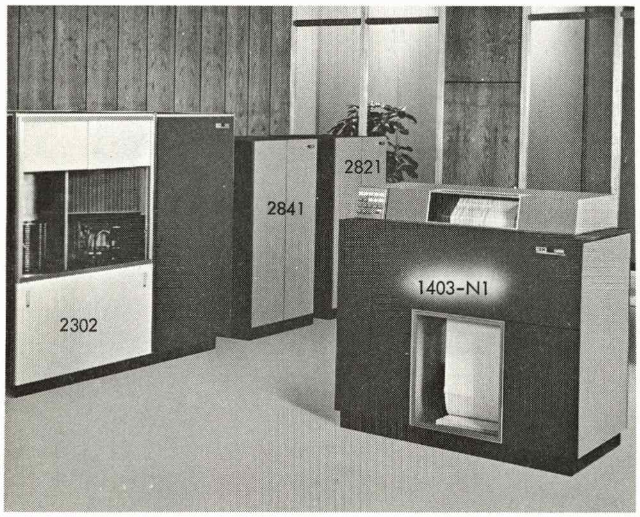


Figure 26. IBM 2302 Disk Storage, 1403 (Model N1) Printer, 2841 Storage Control, and 2821 Control Unit

IBM 2303 Drum Storage

The IBM 2303 Drum Storage (Figure 27) provides direct access storage for 3.91 million bytes on the magnetic surface of a rotating drum. Two 2303's may be attached to each 2841 Storage Control, for total on-line storage of 7.82 million bytes per 2841.

The drum rotates at almost 3,500 revolutions per minute. Its surface is divided into 800 tracks; each track has a maximum data capacity of 4,892 bytes. The data transfer rate to or from the processing unit is 312,500 bytes per second (or 625,000 packed decimal digits and signs).

Because of the assignment of a read/write head to each track, there is no delay in accessing a track. The rotational delay to a specific part of the track ranges

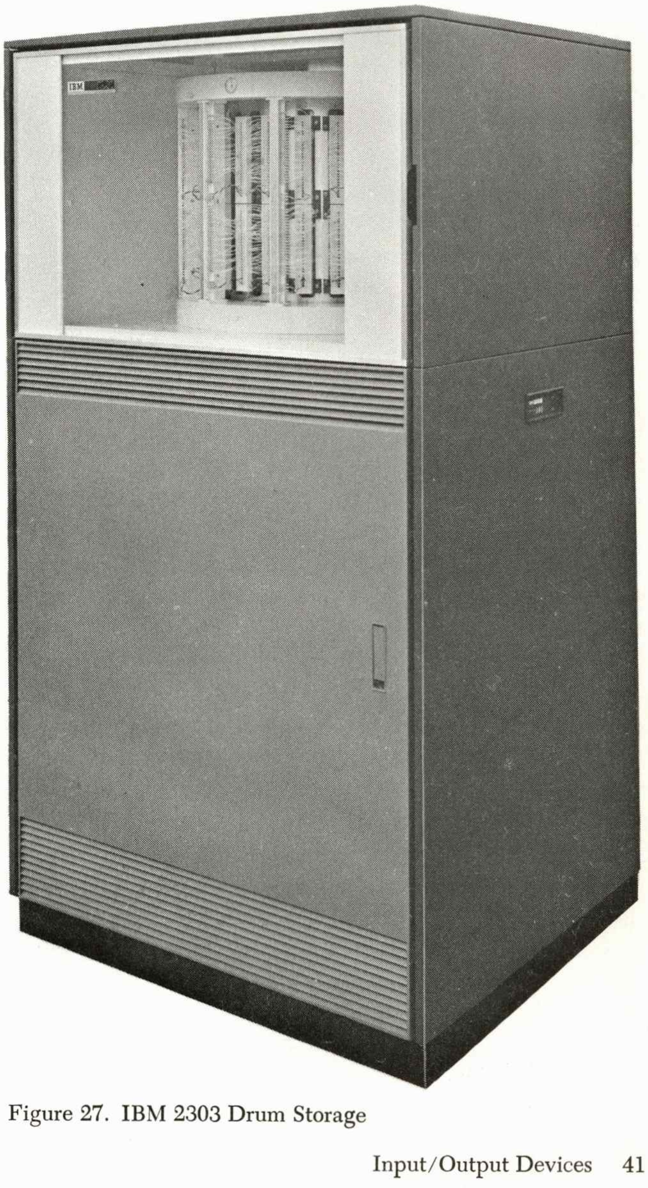


Figure 27. IBM 2303 Drum Storage

from 0 to 17.5 milliseconds and averages 8.6 milliseconds.

The 2303 is used for programming systems residence, rapid access to frequently used data, and other auxiliary storage functions.

IBM 2311 Disk Storage Drive

The IBM 2311 Disk Storage Drive (Figure 19) provides direct access storage for 7.25 million bytes (or 14.5 million packed decimal digits and signs) in a single disk pack. Eight disk storage drives can be attached to each IBM 2841 Storage Control, for a total on-line capacity of 58 million bytes per 2841. In addition, unlimited storage capacity is possible because the IBM 1316 Disk Pack in each drive can be easily removed and replaced with another in less than one minute.

The disk pack weighs only 10 pounds; each has six 14-inch disks, mounted ½ inch apart on a vertical shaft. The inside ten disk surfaces are used for recording data, and the outermost two surfaces are protective plates. When the disk pack is installed in the drive, information is written on or read from the surfaces by magnetic read/write heads, mounted in pairs between each two disks on a movable comb-like access mechanism.

The data rate of the IBM 2311 is 156 thousand bytes per second. Sequential track-to-track access time is 25 milliseconds. The maximum seek time is 135 milliseconds, and the average seek time is 75 milliseconds. The average rotational delay is 12.5 milliseconds.

IBM 2321 Data Cell Drive

The IBM 2321 Data Cell Drive (Figure 28) economically extends on-line direct access storage capabilities to a volume of data beyond that of other storage devices. It provides a very large storehouse of readily available operating data such as part-by-part inventories, shop schedules, customer accounts of large companies, and manpower records.

Each 2321 offers space for 400 million bytes (or 800 million packed decimal digits and signs) of on-line data. Eight 2321's may be attached to a 2841 Storage Control, for a total on-line capacity of 3.2 billion bytes or 6.4 billion packed decimal digits and signs per 2841 control unit. The data rate is 55 thousand bytes per second.

Each data cell drive can contain as many as ten data cells, each having a capacity of 40 million bytes. The data cells are all removable and interchangeable among 2321's, permitting an open ended capacity for data cell libraries.

The storage medium is a strip of magnetic tape 2¼ inches wide by 13 inches long. Each data cell (Figure 29) contains 20 subcells of 10 strips each.

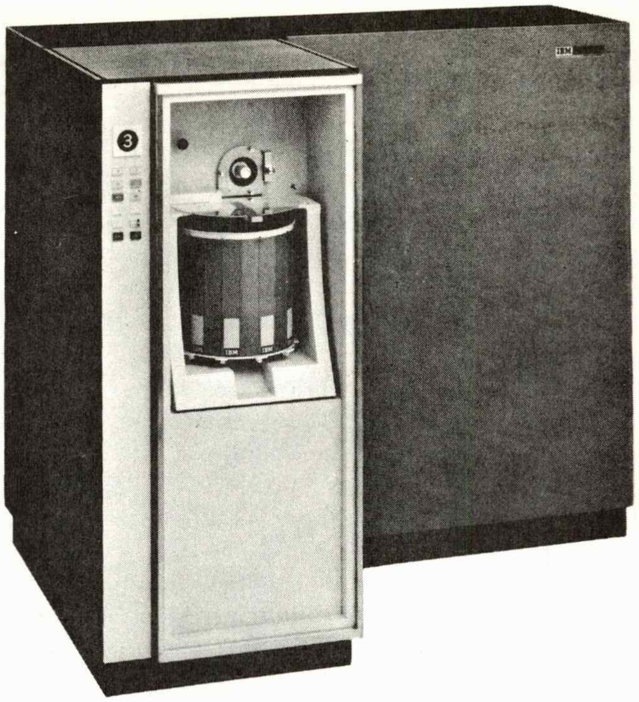


Figure 28. IBM 2321 Data Cell Drive

Upon activation, a data cell drive rotates its circular array of data cells and positions one of the 200 subcells (20 per cell) beneath an access station. Maximum rotation is 100 subcells because the array always rotates in the direction requiring less travel. When the addressed subcell is in position, separation fingers draw the addressed strip from among the 10 strips in the subcell. The strip is then placed on a small drum, rotated past a read/write head, and returned to its subcell.

Each strip has its 100 tracks grouped in five cylinders of 20 tracks; the read/write head is composed of 20 elements and can be moved to any one of five positions. In summary, a specific record is therefore addressed by drive (one of 8), data cell (one of 10), subcell (one of 20), strip (one of 10), cylinder (one of 5), and read/write head element (one of 20). Variable-length records up to 2,000 bytes long can be read and/or written in all available tracks before the strip is returned to its subcell.

Access time to a record varies from 100 microseconds to a maximum of 0.650 second. The minimum time occurs when only switching to another track within the same cylinder is performed and no rotational delay is involved. The maximum time occurs when a previous strip must be returned to its subcell, and the array rotated the maximum distance, before the new strip can be withdrawn and the specific record appear (after a complete rotation of the drum) under the read/write head. These and intermediate times (excluding *drum* rotational delay) are given in Figure 30. Rotational

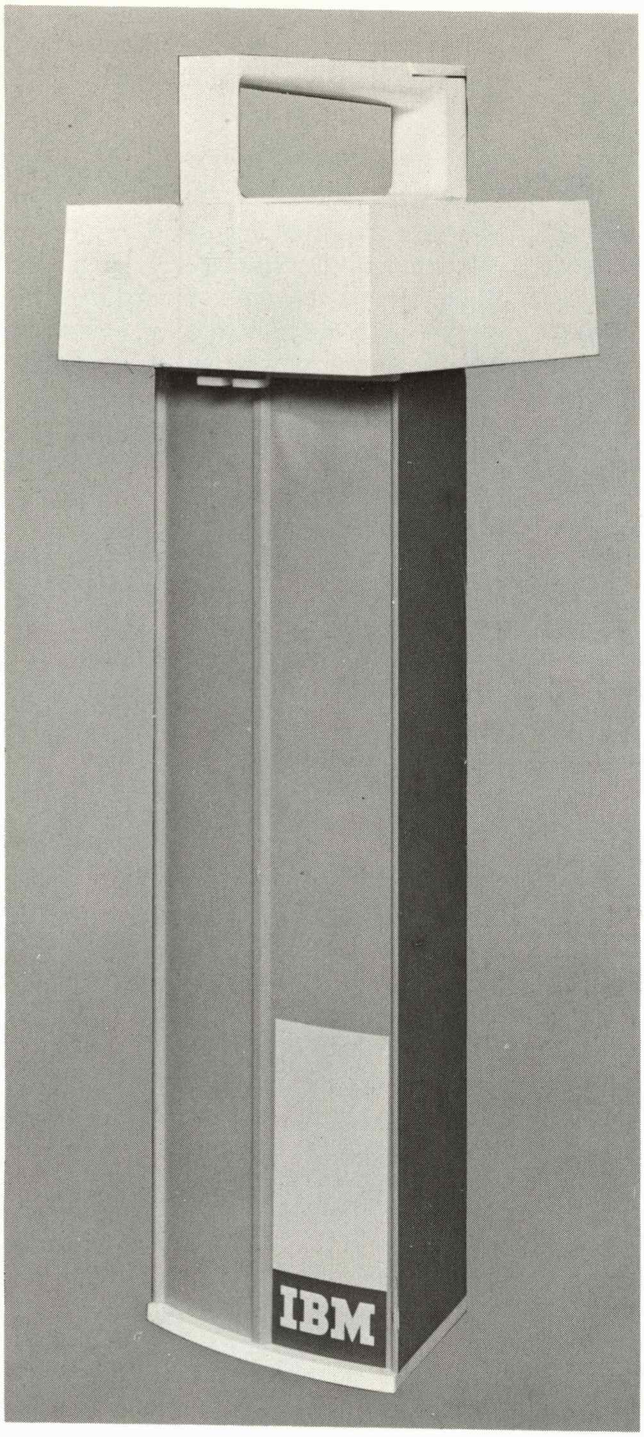


Figure 29. Data Cell

delay is 0 to 50 milliseconds (25 average). The average rotational delay is excluded because it applies only when the record sought is not at the beginning of the track.

Conditions	Time/Number of Subcell Moves			
	0 Subcell	1 Subcell	50 Subcell	100 Subcell
When only Read/ Write element selection is required	100usec			
When only Read/ Write head Block motion is required	95ms			
When No Strip is on the Drum*	175ms	250ms	350ms	400ms
When a previously Addressed Strip is on the Drum*	375ms	450ms	550ms	600ms

* Times given are for access to beginning of track.

Figure 30. IBM 2321 Seek Time

IBM 2841 Storage Control

The IBM 2841 Storage Control (Figure 26) provides the capability of attaching serial-by-bit types of direct access storage devices to the IBM System/360. The following devices can be controlled by the 2841:

	ACCESS MECHANISMS
IBM 2302 Disk Storage Model 3	2
IBM 2302 Disk Storage Model 4	4
IBM 2303 Drum Storage	1 (equivalent)
IBM 2311 Disk Storage Drive	1
IBM 2321 Data Cell Drive	1

These devices can be mixed to provide 2841 control of up to eight *access mechanisms* in any combination not affected by three limitations concerning the 2303:

1. No more than two 2303's can be in the combination.
2. If two 2303's are in the combination, no 2311's can be in the combination.
3. If one 2303 is in the combination, no more than three 2311's can be in the combination.

Thus, each 2841 can control the following discrete quantities:

2302-3 (one module, two access mechanisms)	4
2302-4 (two modules, four access mechanisms)	2
2303	2
2311	8
2321	8

Or, if the devices are mixed, each 2841 can control (for example) one 2302 Model 4 and four 2321's. As another example, each 2841 can control one 2302 Model 3, one 2303, three 2311's, and two 2321's.

The 2841 interprets and executes all orders from the system, and checks the validity of the data transferred to and from the "files" (direct-access storage devices).

Optional Features

The two-channel switch permits switching a 2841 between two channels under program control.

File scan permits searching through direct access storage for a specific record or condition. (This feature is not available for the 2303.)

The additional storage feature enables a 2841 to control and address up to eight additional 2302 access mechanisms or two more 2302's, whichever limitation is reached first, thus providing a way to double the total on-line capacity in 2302's. However, the first eight access mechanisms can still be in the regular combination of files, from none in 2302's to all in 2302's. Limitations are:

1. The total number of attached 2302's, 2303's, and 2321's cannot exceed eight (counting either model of each 2302 as two).

2. The total number of attached 2302's cannot exceed four.

3. Even if no 2302's were attached, no more than two 2302's can be added.

The record overflow feature provides greater utilization of the available storage capacity by allowing a record to "overflow" from track to track to the end of the cylinder (in the 2303, to the end of the drum).

The two-channel switch feature and the additional storage feature cannot be installed together on the same 2841.

IBM 2301 Drum Storage; IBM 2820 Storage Control

The IBM 2301 Drum Storage provides direct access storage of approximately 4 million bytes at a data rate of 1.2 megabytes per second. The high data rate is achieved partially by accessing four tracks in parallel rather than a single track, thus the common reference to this as a "parallel file." The data are recorded on and read from the rotating drum serially by half-byte: first the four high-order bits of the byte, then the four low-order bits.

The 2301 is similar to the IBM 2303 Drum Storage in rotational speed and capacity, and is identical to it in external appearance (Figure 27). The 2301 records data on 800 tracks, divided into 200 addressable groups of four tracks each. Each such conceptual track can contain a single record of 20,483 bytes. Data records can be of variable length and can overflow from track to track. Seek time is zero; rotational delay to any record ranges from 0 to 17.5 milliseconds, and averages 8.6 milliseconds.

The IBM 2820 Storage Control provides the capability of attaching up to four IBM 2301 Drum Storage units to a System/360 channel, for a total on-line direct access capacity of more than 16 million bytes or 32 million packed decimal digits and signs per 2820 attached.

The 2820 interprets and executes all control orders received from the channel, and checks the validity of the data transferred to or from the storage devices.

The optional two-channel switch permits switching a 2820 Storage Control between two channels.

IBM 2314 Direct Access Storage Facility; IBM 2844 Auxiliary Storage Control

The IBM 2314 Direct Access Storage Facility (Figure 31) contains eight independent disk storage drives and their control unit. It also contains a ninth drive that can be brought into use if one of the eight normally addressed drives requires preventive or emergency maintenance.

The eight removable and interchangeable IBM 2316 Disk Packs required by each 2314 provide a total of 233.4 million bytes of on-line disk storage and practically unlimited off-line storage.

In most ways the 2314 is comparable to eight IBM 2311 Disk Storage Drives. Its maximum, average, and minimum access times are 135, 75, and 25 milliseconds respectively, as in the 2311. Average rotational delay in both machines is 12.5 milliseconds. Each drive in the 2314 operates independently, as do eight 2311's. Both machines use the removable disk pack method of storing data. The integral control unit for the 2314's provides the same functions as the 2841 provides for 2311's.

However, the capacity of the 2316 disk pack is four times that of the 1316 disk pack used with the 2311, and the total capacity per control-unit position on a channel is four times that of eight 2311's. (See Figure 32.) The data rate of the 2314 is 312,000 bytes per second, exactly double that of the 2311.

Each of the eight disk packs in the 2314 has a capacity of 29.17 million bytes (or 58.35 million packed decimal digits and signs). Each of the 20 disk recording surfaces is divided into 200 concentric tracks; each track has a capacity of 7,294 bytes.

The 2314's conceptual cylinders are composed of 20 tracks, one on each disk surface. With 7,294 bytes per track, 145,880 bytes are thus available under each of the eight access mechanisms in a 2314. Within a cylinder, multiple records can be read or written through the use of command chaining, without rotational delay between records.

File scan and record overflow are standard features. File scan permits a comparison on selected bytes—in effect, a search through the file for a specific record or condition. Record overflow increases the utilization of the storage by allowing a record to overflow from track to track to the end of the cylinder.

One two-channel switch, a special feature, is permitted per 2314. The switching is under program control and (as with files under control of the 2820 or 2841 storage control) may be used to switch the 2314 between two channels of a system or two systems.

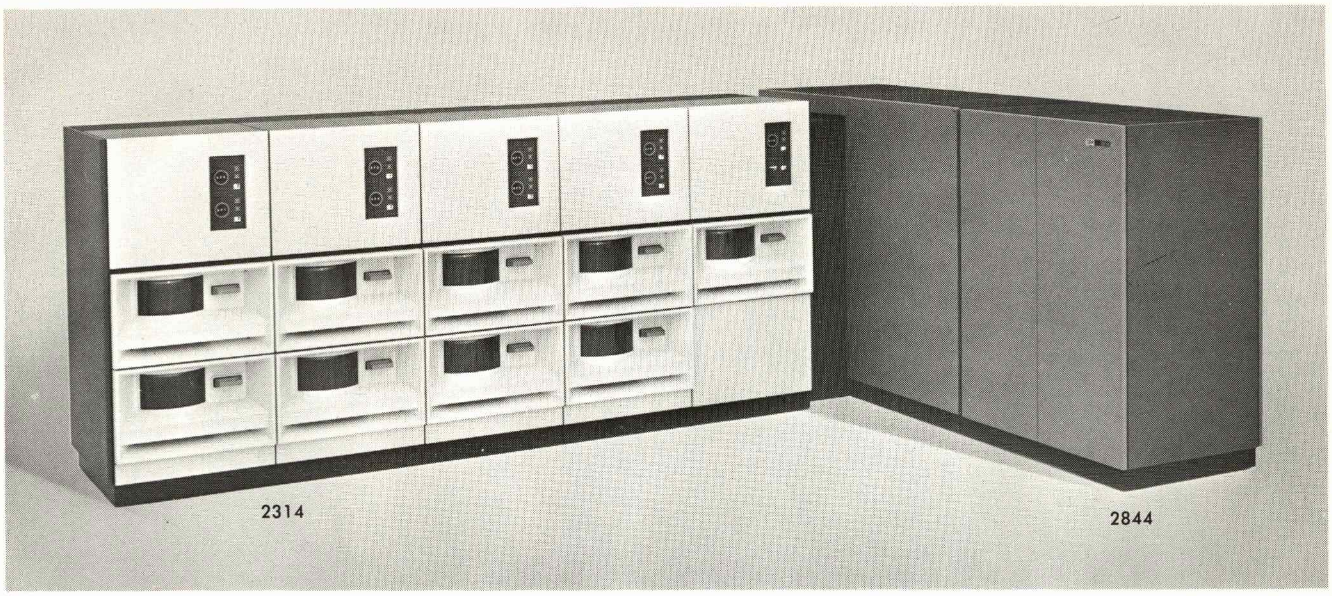


Figure 31. IBM 2314 Direct Access Storage Facility and 2844 Auxiliary Storage Control

IBM 2844 Auxiliary Storage Control

When the 2314 is provided with the 2844—a second, functionally identical control unit—these advantages are added:

1. A second path to the data. With the 2844 on a different channel of the same system (possible on Model 50 and larger), this increases throughput by permitting overlapped data transfers on any two drives. Also, the existence of two control units provides an alternative path to the data, should one control need preventive or emergency maintenance.
2. Under program control, any of the eight active drives in the 2314 may be switched between the two control units.

File scan and record overflow are standard features of the 2844. A two-channel switch may be installed on both the 2314 and the 2844, thereby providing communications between the eight drives of the 2314 and up to four selector channels on one or more processing units (excluding two channels on the same Model 30 or 40).

Single-Disk Storage Drive

The single-disk storage drive, a standard part of the CPU for Model 44, provides direct access storage for 1,171,200 bytes on a single disk that is permanently enclosed in an IBM 2315 Disk Cartridge, with side access to the CPU for replacement of cartridges. (All cartridges are available separately.)

The data rate of the disk storage is 90,000 bytes per second. Average access time is 70 milliseconds; average rotational delay is 20 milliseconds.

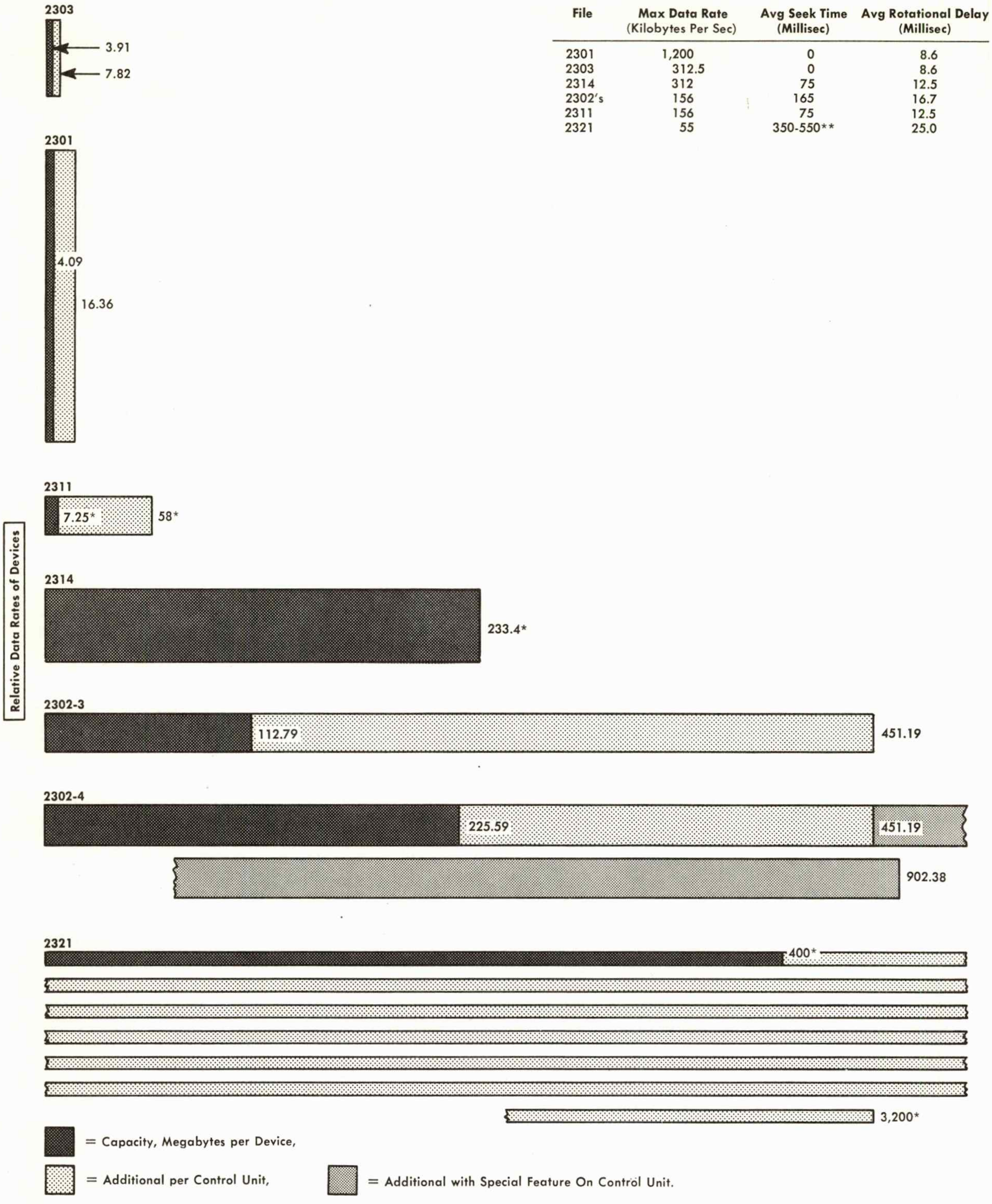
The disk is organized in 200 cylinders; a cylinder consists of a pair of tracks, one track per disk surface. Each cylinder contains 16 sectors, eight per track and surface. Each sector has a length of 366 bytes; the formal record length is 2,928 bytes (eight sectors).

No programming compatibility exists between the single-disk storage drive and disk storage drives controlled through the IBM 2841 Storage Control.

The drive is attached to the channel via an adapter, also installed in the CPU as a standard feature. A second drive may be installed in the CPU, as a special feature, to double capacity. Both drives operate on one shared subchannel requiring one control-unit position on the channel.

Figure 32 summarizes and compares the data rates, capacities per device and per control unit, and average access times of all direct access storage devices.

File	Max Data Rate (Kilobytes Per Sec)	Avg Seek Time (Millisec)	Avg Rotational Delay (Millisec)
2301	1,200	0	8.6
2303	312.5	0	8.6
2314	312	75	12.5
2302's	156	165	16.7
2311	156	75	12.5
2321	55	350-550**	25.0



*Interchangeable data storage media also provide an unlimited off-line capacity.

**Variable with the kind of access; see Figure 30.

***Not shown is the disk storage uniquely a part of the CPU for Model 44. Its data rate of 90 kilobytes, and capacities of 1.17 megabytes for one drive or 2.34 for two, are about 30% those of the 2303. See "Single-Disk Storage Drive."

Figure 32. Comparative On-Line Capacities and Speeds of Files Used with System/360

Card Input/Output

IBM 1442 Card Read Punch Model N1

The IBM 1442 Card Read Punch Model N1 uses a single common card path for reading and punching, and reads and punches cards serially by card column. Serial card feeding, past a read and then a punch station, makes it possible for the program to read data from a card and then punch data (such as the results of a calculation) into the same card during a single card pass. The IBM 1442 Model N1 reads or punches cards at the following maximum rates:

Reading — 400 cards per minute
Punching — 160 card columns per second (see note)

NOTE: Punching speed depends on the location of the last column punched. Interspersed blank columns between fields are considered punched columns. In terms of cards per minute, the rated speed for punching columns 1-10 is 265 cpm; for punching columns 1-80, 91 cpm.

No external control unit is required; the control circuits are within the 1442. The 1442 is not buffered.

The read hopper holds 1,200 cards. Card movement is from the hopper to the read station, to the punch station, then to one of the two stackers (pockets). The stackers hold 1,300 cards each, and cards can be removed from either stacker without stopping the machine.

The appearance of the unit is nearly identical to that of the 1442 Model N2 shown in Figure 33.

Data Mode 1

In data mode 1, the 1442 Model N1 can read and punch the 256 different combinations of holes required for the extended binary coded decimal interchange code (EBCDIC). For 256 combinations, multiple punches in a single card column are required; however, no more than one punch is permitted in rows 1-7. (Rows 12, 11, 0, 8, and 9 allow 32 possible combinations which, multiplied by the eight possibilities in rows 1-7, equal the required 256.) For multiple punches in rows 1-7 as well, the special card image feature is required.

Data Mode 2

Operations using the card image feature are in data mode 2, which is the card image or column binary mode. The card image feature permits the low-order six bits of bytes read from the processing unit to be punched alternately into the upper six and lower six rows of a card, enabling 160 such truncated bytes to be placed in the card. On reading, the information is read column by column and transmitted to the processing unit byte by byte, with two high-order bits (0 and 1) being set to zero.

IBM 1442 Card Punch Model N2

The IBM 1442 Card Punch Model N2 (Figure 33) may be connected to the System/360 to provide the card punching function only. Punching operations, speeds, internal controls, punching in data mode 2, and all other features related to punching are identical to those of the IBM 1442 Card Read Punch Model N1, except that the 1442 Model N2 has only a single 1,300-card stacker.

IBM 2501 Card Reader Models B1 and B2

Models B1 and B2 of the IBM 2501 Card Reader (Figure 34) are externally identical, but the maximum card-reading rate of Model B1 is 600 per minute; of Model B2, 1,000 per minute. The Model B1 can be used for primary card input or as a console reader for the larger models of the System/360. Model B2 can be used for primary card input, often in conjunction with the IBM 2520 Card Punch Model B2 for maximum card processing speeds.

No external control unit is required; the control circuits are within the 2501. The 2501 is not buffered.

Reading of cards is accomplished by photocells that convert the light passing through punched holes into electrical energy. Cards are read serially by column. The feed hopper has a 1,200-card capacity, and cards can be removed from the single 1,300-card stacker without stopping the reader.

The 2501 can read the EBCDIC in the standard data mode 1. For the 256 combinations in the EBCDIC, multiple punches in a single card column are required;

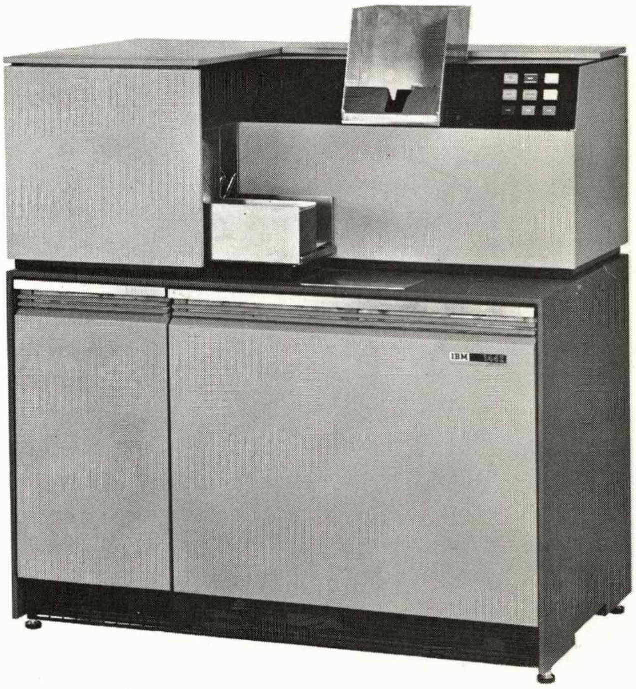


Figure 33. IBM 1442 Card Punch Model N2

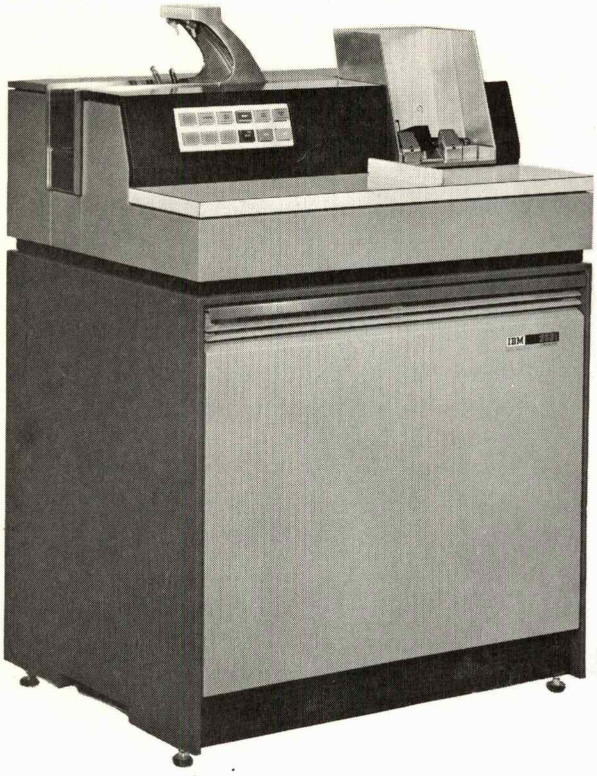


Figure 34. IBM 2501 Card Reader

however, no more than one punch is permitted in rows 1-7. For multiple punches in rows 1-7 as well, the special card image feature is required. For a description of reading in the card image mode, see "Data Mode 2" in the 1442-N1 text.

IBM 2520 Card Read Punch Model B1

The IBM 2520 Card Read Punch Model B1 (Figure 35) both reads and punches cards at a maximum rate of 500 per minute. Operation of the 2520 Model B1 is the same as for the 1442-N1 or 2501 with respect to serial-by-column card reading, and is like the 1442-N1 in that:

1. The feed hopper has a 1,200-card capacity.
2. Cards can be removed from either 1,300-card stacker while the machine is running.
3. Cards are moved past first a read and then a punch station.
4. Prepunched cards can be fed through the punching station without a special feature.

As in the 2501, reading of cards is accomplished by photocells that convert the light passing through punched holes into electrical energy.

The punching operation of the 2520 differs, however, from that of the 1442, being parallel by row instead of serial by column. Each card is fed in parallel and read serially while the preceding card, its axis turned 90 degrees, is passing the punching station (Figure 36).

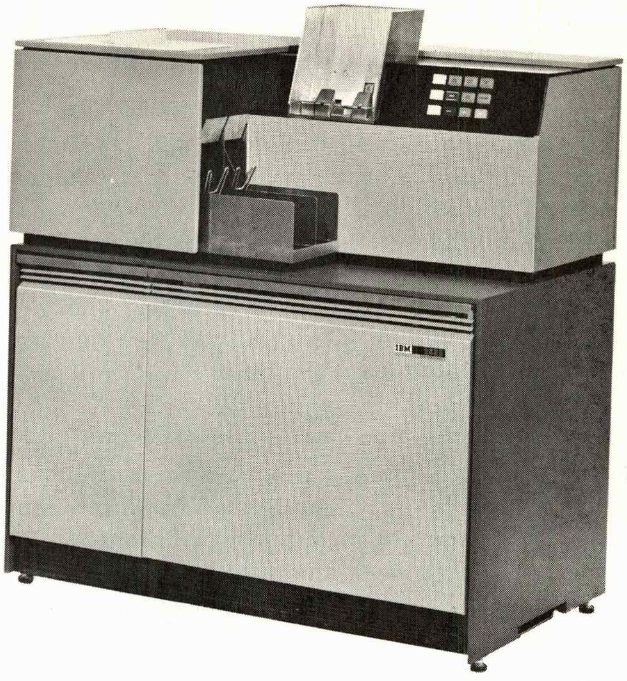


Figure 35. IBM 2520 Card Read Punch Model B1

No external control unit is required; the control circuits are internal. The 2520 punching operations are buffered; the reading operations are not buffered.

The 2520 can read and punch the EBCDIC in the standard data mode 1. For the 256 combinations in the EBCDIC, multiple punches in a single card column are required; however, no more than one punch is permitted in rows 1-7. For multiple punches in rows 1-7 as well, the special card image feature is required. For a description of reading and punching in the card image mode, see "Data Mode 2" in the 1442-N1 text.

IBM 2520 Card Punch Models B2 and B3

The IBM 2520 Card Punch Model B2 or B3 may be connected to the System/360 to provide the punching function only. Models B2 and B3 are externally identical (and the same as the 2520-B1 shown in Figure

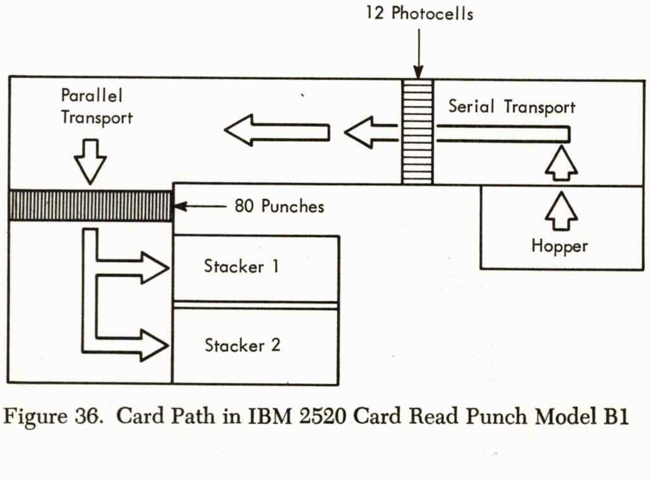


Figure 36. Card Path in IBM 2520 Card Read Punch Model B1

35), but the maximum card-punching rate of Model B2 is 500 per minute; of Model B3, 300 per minute.

Internal controls, punch buffering, punching in data mode 2, the punching speed of Model B2, and all other features related to punching are identical to those of the IBM 2520 Card Read Punch Model B1.

IBM 2540 Card Read Punch

The IBM 2540 Card Read Punch (Figure 37) reads cards at a maximum rate of 1,000 per minute, and punches cards at a maximum rate of 300 per minute. The card reading and punching sections are separate entities, and reading and punching can take place simultaneously.

The read hopper, with its file feed, holds 3,100 cards. Five 1,350-card stackers are located between the read and punch ends of the 2540; three stackers can be used in reading and three in punching. The center pocket can be fed with either punched or read cards, but should be reserved to one or the other during a run. Cards can be removed from any pocket without stopping the machine.

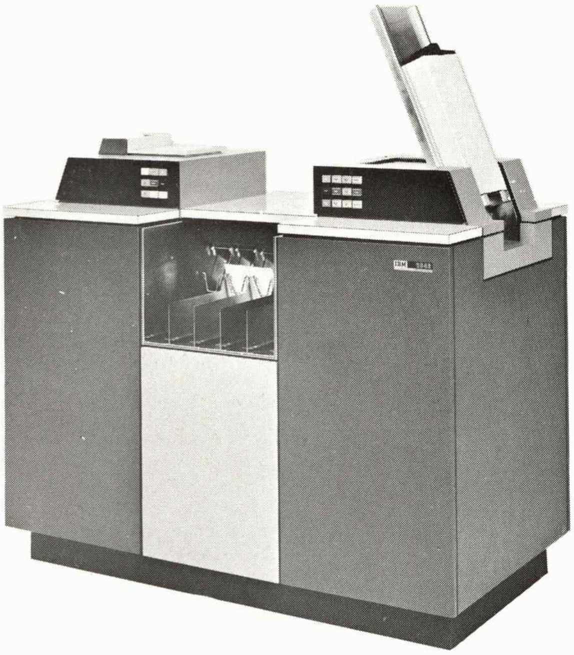


Figure 37. IBM 2540 Card Read Punch

The 2540 is controlled, buffered, and attached to the channel by a control unit (see "IBM 2821 Control Unit Models 1-5").

An optional 51-column interchangeable read feed feature permits the feeding of either 51-column cards or standard 80-column cards in the read feed of the machine. The 51 columns correspond to columns 15-65 of an 80-column card. (Fifty-one column cards may be postal money orders, installment payments, inventory cards: for example, a detached 51-column stub from an 80-column card.) Installation of this feature permanently reduces the maximum card-reading speed to 800 cards per minute. The first two read pockets are modified so that the operator can adjust for either 80- or 51-column operation. During the time that the pockets are set for 51-column cards, the capacity of the two pockets is reduced to 800 cards each and longer cards cannot be fed.

An optional punch feed read feature enables the 2540 to punch output data into the same card from which input data were read. (Column binary cards cannot be read in the punch feed.) Unless this feature is installed, only blank cards can be fed through the punching section.

The 2540 can read and punch the EBCDIC. For the 256 combinations in the EBCDIC, multiple punches in a single card column are required; however, no more than one punch is permitted in rows 1-7. For multiple reading or multiple punches in rows 1-7 as well, the column binary special feature must be installed on the 2821. Column binary cards are read or punched exactly as described under "Data Mode 2" in the 1442-N1 text.

Figure 38 summarizes the essential characteristics of all card equipment discussed.

Card Unit	Read Speed (Cards Per Min)	Punch Speed	Read and Punch Same Card?	Self-Contained Control Unit?	Buffers
1442-N1	400	160 card col per sec †	yes	yes	none
1442-N2	---	160 card col per sec †	---	yes	none
2501-B1	600	------------------	---	yes	none
2501-B2	1,000	------------------	---	yes	none
2520-B1	500	500 cards per minute	yes	yes	punch
2520-B2	---	500 cards per minute	---	yes	punch
2520-B3	---	300 cards per minute	---	yes	punch
2540	1,000*	300 cards per minute	yes	no	read and punch

* 800 if 51-column interchangeable read feed feature is installed.

† 265 cards per minute punching columns 1-10; 91 cards per minute punching all 80 columns.

Figure 38. Basic Comparison of Card Equipment for System/360

Printers

IBM 1053 Printer Models 1 and 4

The IBM 1053 Printer (Figure 39) is a small unit similar to the IBM 1052 Printer-Keyboard (Figure 15) but has the printer function only and no keyboard for entry of data. The 1053 prints at 14.8 characters per second.

The 1053 can be connected to the system in three ways, of which the first and second apply to the 1053 Model 1 and System/360 Model 30, and the third applies to the 1053 Model 4 and System/360 Models 30-91:

1. Via the IBM 1051 Control Unit Model N1, providing either:
   a. the printing function alone, being installed in place of an IBM 1052 Printer-Keyboard Model 6 or 8 and operating with no other I/O devices of a 1050 system.
   b. the printing function together with (or instead of) the functions of an IBM 1052 Printer-Keyboard Model 5 and, in addition, those of some other local I/O devices of a 1050 system. (See "IBM 1052 Printer-Keyboard Models 3, 5, 6, 7, and 8.")
2. Via the IBM 1051 Control Unit Model 1, providing the same functions (item 1a or 1b) as when connected via the 1051 Model N1; the only differences are that the 1052 used for the function under item 1b is a Model 3 and the 1051 Model 1 may also connect remote 1050 systems for off-line operations. Other 1053's may be included in the remote 1050 systems. (See "IBM 1050 Data Communication System.")
3. Via the IBM 2848 Display Control for printout in a display application. (See "IBM 2260 Display Station.")

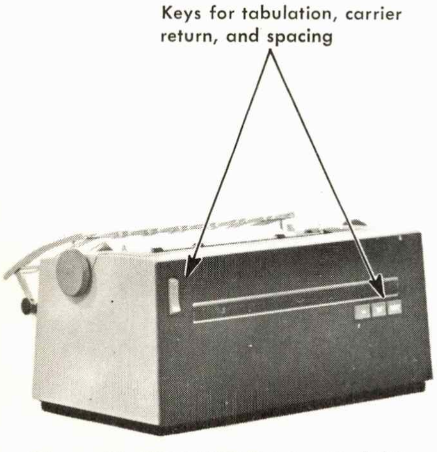


Figure 39. IBM 1053 Printer Model 1

Attachment Via 1051

When the 1053 Model 1 is attached via one of the 1051 control unit models, it has an interchangeable printing sphere and prints a maximum line length of 13 inches. Line spacing (either 6 or 8 to the inch), character spacing (either 10 or 12 to the inch), and the font of each printing sphere are as specified by the customer.

Several special features are available for the 1053 having this connection, including a forms feed that provides control over the vertical movement of continuous paper forms, and an accelerated carrier return feature for speeding the carrier return time to about half that of a standard 1053.

Attachment Via 2848

The 1053 Model 4, attachable via the 2848 display control, differs in the following ways from a 1053 Model 1:

1. The functions of the four keys for tabulation, carrier return, and spacing control are not provided.
2. Alternate printing spheres may not be specified; the character set is considered fixed.
3. The accelerated carrier return and forms feed special features are not available.
4. A power on/off key and light assembly is added.

IBM 1403 Printer Models 2, 3, 7, and N1

Four different models of the IBM 1403 Printer (Figures 26 and 40) can be attached to the System/360:

PRINTER MODEL	PRINTING POSITIONS	MAXIMUM RATED SPEED (Lines Per Minute)
1403-2	132	600
1403-3	132	1,100
1403-7	120	600
1403-N1	132	1,100

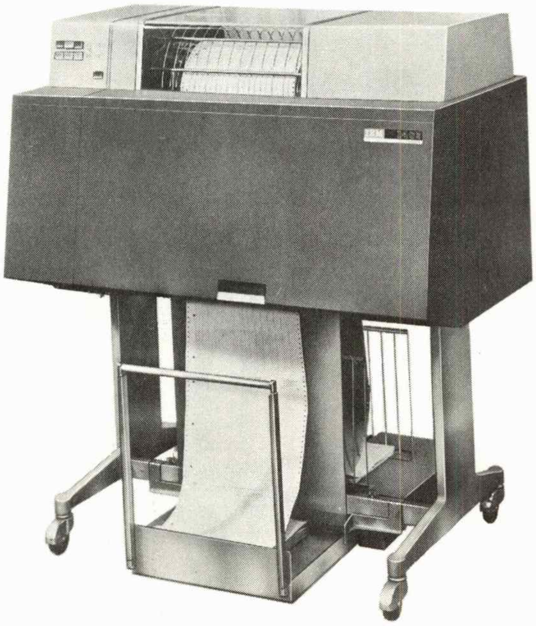


Figure 40. IBM 1403 Printer Models 2, 3, and 7

The Models 2, 3, and N1 can be operated at still higher speeds through the use of the universal character set described under a following heading.

Any model of the 1403 printer is controlled and buffered by the 2821 control unit, which also provides the attachment to a System/360 channel. One, two, or three 1403's can be controlled by each 2821, depending on the 2821 model. (See "IBM 2821 Control Unit Models 1-5.")

The 1403 Model 2 or 7 uses a chain of linked characters for printing, and the Model 3 or N1 uses a train of characters not linked together. As an optional feature, an interchangeable chain cartridge adapter is available for the Model 2 or 7. (At least one IBM 1416 Interchangeable Train Cartridge is required for each Model 3 or N1.) Either cartridge adapts the 1403 for quick and convenient changing of type fonts or character arrangements for special printing jobs.

Characters are printed ten to the inch, and lines are spaced either six or eight to the inch under operator control. An auxiliary ribbon feeding special feature adapts the Model 2 or 7 for the use of polyester ribbons giving sharper impressions. This feature is standard on Models 3 and N1.

The 1403 Model 7 is the only attachable model that does not have a dual-speed carriage—a feature that provides high-speed skips at 75 inches per second when skipping is more than eight lines. Skipping speed on the Model 7 is 33 inches per second.

The 1403 Model N1 (Figure 26) differs from all other models in featuring sound-absorbent covers extending to the floor, power-operated front and top covers, and a newly designed forms cart; otherwise, it is the same as Model 3.

The selective tape listing feature and the universal character set feature are available for the 1403 Models 2, 3, and N1.

Selective Tape Listing

The selective tape listing feature provides the capability of substituting longitudinal strips for the normal paper sheet forms. Four 3.1-inch tapes, eight 1.5-inch tapes, or a combination of these less than 13.2 inches wide, may be printed. Up to 29 characters can be printed on a 3.1-inch tape, or up to 13 on a 1.5-inch tape. Each tape is individually line-spaced under program control, with no skipping permitted. Changing from tapes to standard forms, or vice versa, is easily accomplished by an operator.

A newer selective tape listing feature is available for a 1403 Model N1 used on System/360 Models 30, 40, and 50. It permits skipping at the rate of 33 inches per second over a distance fixed by Field Engineering adjustment at a value within the range of 3 to 22 inches; this is in lieu of the repetitive line spacing required by the other version of the feature. Operation is quieter. Changeover from tape listing mode to full-sheet printing is made still easier; this and other new operator conveniences have a beneficial effect on the feature's overall efficiency.

Universal Character Set

The universal character set feature (UCS) provides the user with the ability to load from cards, into a special storage area in the IBM 2821 Control Unit, any set of discrete codes up to a maximum of 240. The codes in 2821 storage correspond specifically and sequentially with the characters on the train or chain. The user may order any characters for a given set, including custom designs for special applications.

The chain or train has 240 type positions, which, prior to UCS, were divided into five identical sets of 48 characters each. The rated maximum printing speed of a given printer is based, partially, on this division into five identical sets. If characters are included only one, two, or even four times on the chain or train, the rated maximum printing speed is necessarily reduced. The reduction, however, is not linear, because of other factors than the number of character sets (e.g. single spacing vs. skipping). Conversely, if the characters are included *more* than five times, the printing speed is increased beyond the rated maximum.

As already indicated, the 1403 Model 2 has a maximum rated speed of 600 lines per minute (lpm) when its chain contains the conventional five sets. If the installed set contains 240 different characters—the widest possible variety—printing takes place on the 1403 Model 2 at up to 140 lpm. Under the same conditions, printing takes place on the 1403 Model 3 or N1 at up to 310 lpm. The maximum printing speeds, with UCS, are controlled electronically and are 750 lpm for Model 2, and 1400 lpm for Model 3 or N1.

IBM 1404 Printer Model 2

The IBM 1404 Printer Model 2 (Figure 41) can print on continuous paper forms at a speed of 600 lines per minute, or it can print on cards at a maximum rate of 800 cards per minute.

In printing on continuous forms, the 1404 operates exactly like a 1403 Model 2: it has 132 printing positions, the same horizontal and vertical spacing, a dual-speed carriage, and all other 1403 Model 2 standard features; however, the auxiliary ribbon feeding, selective tape listing, and universal character set special features are not available for the 1404.

When the card feed is engaged, the 1404 accepts cards, of a variety of lengths and one or two at a time, for printing. Lengths can range from 51 columns to 160

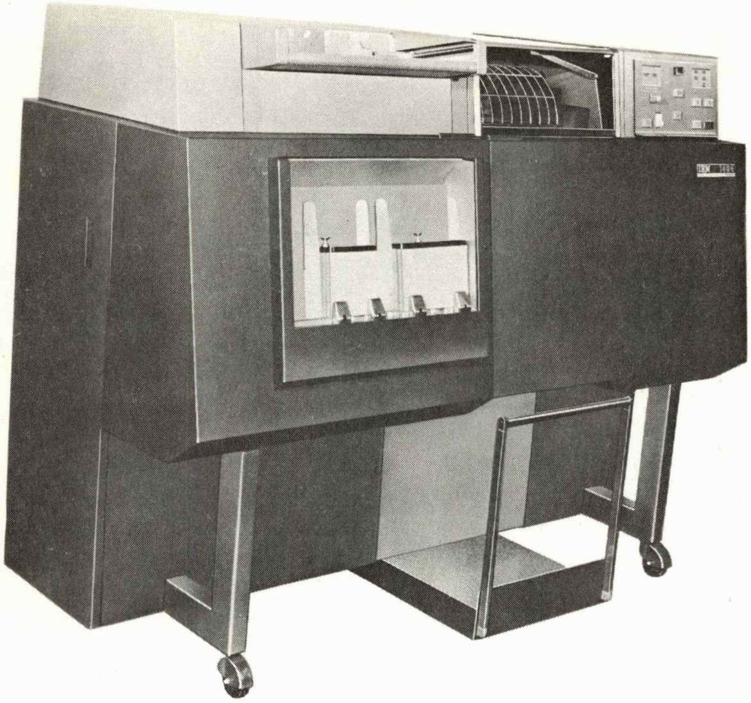


Figure 41. IBM 1404 Printer

columns (80-column card with 80-column stub). Cards from 51 to 80 columns long can also be fed side by side ("two up"); when this is done, the cards may be intermixed in any combination within the 51-80 column-length range; the 800-card per minute rate is reached by this doubled throughput.

As many as 25 lines of data can be printed on each card fed. With the optional read-compare feature, punched information (up to 30 columns) from the card itself may be printed on the card during the same pass—or used as a base for computations by the system, with the results being printed on the same or any following card (depending on the program). For example, data on the card, such as a social security number, can be compared with the equivalent number in a tape record as a check before additional information from tape is printed on the card. The 30 columns of "comparable" information may be non-contiguously selected from among any of the 160 card columns.

The 1404 is controlled, buffered, and attached to the System/360 by an IBM 2821 Control Unit Model 4.

The 1404 uses a chain of linked characters for printing. As an optional feature, an interchangeable chain cartridge adapter is available to adapt the printer for quick and convenient changing of type fonts or character arrangements for special printing jobs.

IBM 2821 Control Unit Models 1-5

The IBM 2821 (Figure 26) contains the control and buffer circuitry to transmit information between the associated System/360 channel and the IBM 2540 Card Read Punch, and/or one of the following printers: IBM 1403 Printer Model 2, 3, 7, or N1, or IBM 1404 Printer Model 2. The 2821 is in five models, each providing control for a specific type and quantity of I/O:

2821	PRINTERS		ALSO 2540 CARD READ	MAX UNITS CON-
MODEL	MAX NO.	TYPE AND MODEL	PUNCH?	TROLLED
1	1	1403-2, 7, 3*, or N1*	yes	2
2	1	1403-2, 7, 3*, or N1*	no	1
3	2 (or 3*)	1403-2, 7, 3*, or N1*	no	2 (or 3*)
4	1	1404-2	yes	2
5	2 (or 3*)	1403-2, 7, 3*, or N1*	yes	3 (or 4*)

*Requires a special feature.

The buffers in the 2821 permit the transfer of accumulated data to and from the channel at a much faster rate per byte than would be possible by direct transfer to or from the attached device.

The column binary special feature can be installed on the 2821 Model 1, 4, or 5 to allow multiple punching in rows 1-7 of a card column, or reading of such multiple punches, by the 2540. This feature is *not* required to read or punch the EBCDIC. (See "IBM 2540 Card Read Punch.")

On Model 67, a two-channel switch feature is available to switch the control unit (2821 Models 1-3 and 5) between two channels. An appropriate no-charge adapter is also added to the 2540 to allow independent operation of the read and punch feeds from two different channels.

IBM 1443 Printer Model N1

The IBM 1443 Printer Model N1 (Figures 42 and 43) prints from 200 to 600 (maximum) lines per minute, depending on the number of characters in the set being used:

13-character set — 600 lines per minute
39-character set — 300 lines per minute
52-character set — 240 lines per minute
63-character set — 200 lines per minute

The 52-character set is standard, and the other sets are available through the selective character set special feature. The user may order any characters for any set, including custom-made designs of special graphics.

The standard printed line for all sets is 120 characters long, spaced horizontally at 10 characters to the inch. Twenty-four additional printing positions are available as a special feature, raising the total number of printing positions to 144.

All characters of the print set are on a single type bar that moves back and forth across the paper. The bar is so made that each different character passes each print position. Printing takes place when the character to be printed corresponds with the character read from the printer's self-contained storage buffer.

A tape-controlled carriage, working under program control, advances paper and provides the vertical print formats. Lines are spaced six or eight to the inch under operator control. Skipping is 15 inches per second.

No external control unit is required; the control circuits and print storage buffer are within the 1443 Model N1.

IBM 1445 Printer Model N1

The IBM 1445 Printer Model N1 can print, in magnetic ink, American Banking Association-approved type font E13B characters (Figure 44), as well as conventional type characters, on the same document. The magnetic ink ribbon can be replaced by the operator with a standard ribbon for conventional printing in non-magnetic ink.

All characters are printed eight to the inch (rather than the usual ten) and up to 113 characters can be printed per line. Lines are spaced six or eight to the inch under operator control. Skipping is 15 inches per second.

The standard type bar for the 1445 contains 56 characters: all 14 of the E13B characters, plus 42 alphameric and special characters. Selective character set, a special feature, adds two separate sets: a 14-character numeric set and a 42-character alphameric set. Neither of these extra sets normally includes E13B characters. Maximum printing speed is from 190 to 525 lines per minute, depending on the number of characters in the set being used:

56 characters (alphameric and E13B)	190 lines per minute
42 characteers (alphameric)	240 lines per minute
14 characters (standard numeric)	525 lines per minute

The 1445 is practically the same in appearance as the 1443 printer shown in Figure 42. Operation of the type bar and tape-controlled carriage is as described for the 1443. Like the 1443, the 1445 contains its own control circuits and storage buffer.

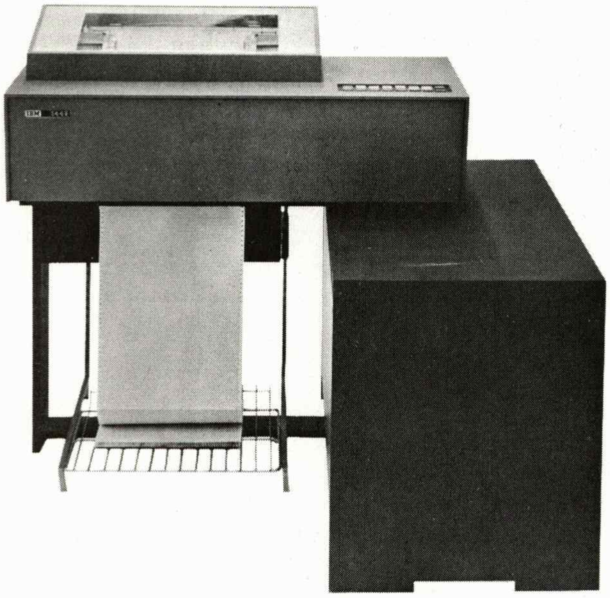


Figure 42. IBM 1443 Printer Model N1

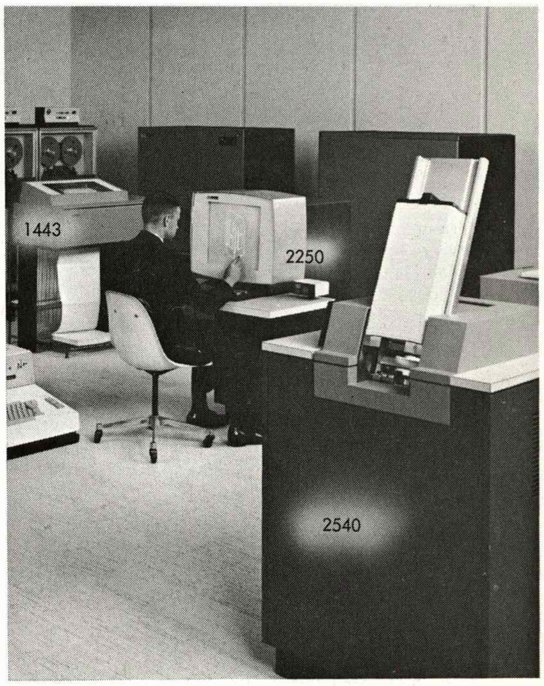


Figure 43. IBM 1443 Printer and 2250 Display Unit

Magnetic Ink

IBM 1412 Magnetic Character Reader;
IBM 1419 Magnetic Character Reader

An IBM 1412 or 1419 Magnetic Character Reader can be attached to a System/360 channel for reading magnetically-inscribed data on checks and other banking documents (Figure 44). The 1412 and 1419 differ mainly in document-reading rates: the 1412 reads at speeds as high as 950 documents per minute; the 1419, at speeds as high as 1,600 per minute. (The 1419 is shown in Figure 45.) Specific speeds depend on document length as well as on the program.

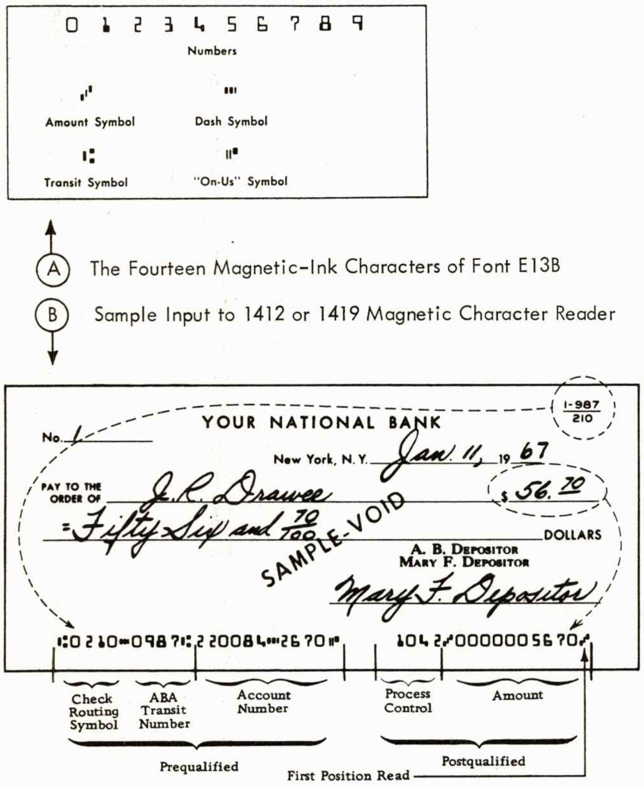


Figure 44. Magnetic Inscription—Translation of Characters and Definitions of Fields

As the documents are read, they may be sorted into as many as 13 classifications: A, B, 0-9, and R (reject). All magnetic inscriptions can be validity-checked.

Documents read may be of intermixed sizes and thicknesses, as typically encountered in check-handling operations. The standard minimum length is 6 inches; shorter documents, such as the 51-column postal money order, can be read into the system, by the 1419 only, at a maximum rate of 1,960 per minute.

These shorter documents can be intermixed with standard-length documents, and can also be sorted if a no-charge special feature for that purpose is installed. If the feature is not installed on the 1419, 51-column cards and other documents less than 5 inches long are sent to the reject pocket. If the feature is installed, 1419 speed is reduced by an amount that increases slightly with the average length of documents and is 4.3 percent for 51-column cards, and 5.3 percent for 6-inch checks.

Many special features are available for both the 1412 and 1419, including an endorser to print the bank's endorsement on the back of each document at no reduction in operating speed. Other features most applicable to on-line operations with the System/360 are:

READER	FEATURE	PURPOSE
1412, 1419	Dash Symbol Transmission	Distinguish U. S. from Canadian transit-routing numbers (leftmost eight magnetic digits), to prevent duplications.
1419	Batch Numbering	(Self-evident)
1412, 1419	Self-Checking Number	Automatically perform mathematical proof that account numbers are correctly recorded and read.
1419	Program Control for Pocket Lights	Improve control of output batches. Stops the reading-sorting and turns on pocket light(s) when a predetermined number of documents has entered one of the corresponding six pockets (with a second feature, 12 pockets) designated by the program.

One 1412 can be attached to a system. A single 1419 or dual 1419's (each requiring a control-unit position on a channel) may be attached to the system.

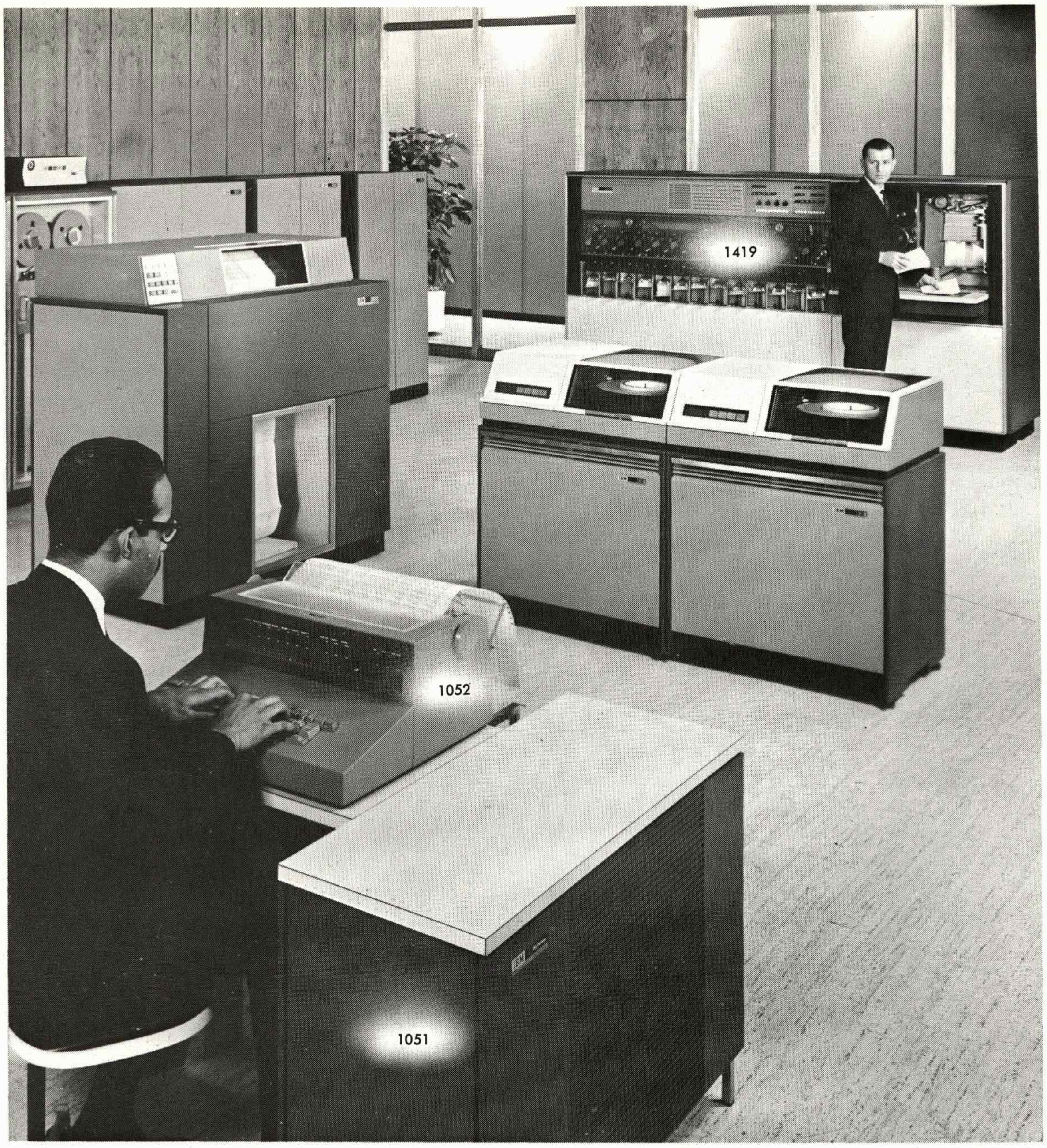


Figure 45. IBM 1419 Magnetic Character Reader, 1052 Printer-Keyboard, and 1051 Control Unit

Optical

IBM 1231 Optical Mark Page Reader Model N1

The IBM 1231 Optical Mark Page Reader Model N1 can be attached to a System/360 channel for direct reading of marks made by an ordinary No. 2 lead pencil in specified places on 8½ by 11-inch paper data sheets. Figure 46 shows the 1231 and a portion of a data sheet.

The marks may also be made by a 1403 Printer, or by a 1443 Printer (for example, a 1443 Model N1 having a 52- or 63-character type bar), provided that the standard dash on the type chain, train, or bar is replaced with an enlarged dash. Fiber optics are used to read the marks; light is transmitted from a single light-bulb source, through tubes made of glass fibers, around internal assemblies to the scanning stations.

The data sheets are fed through the reader from a 600-sheet hopper and are stacked, in reverse sequence, in a 600-sheet stacker or (if an error is detected) in a separate 50-sheet stacker.

Each data sheet has, on one side, up to 1,000 pre-printed positions for marks, and may be so printed on both sides. The sheets are read one side at a time at a maximum constant rate of 2,000 per hour, or one each 1.8 seconds.

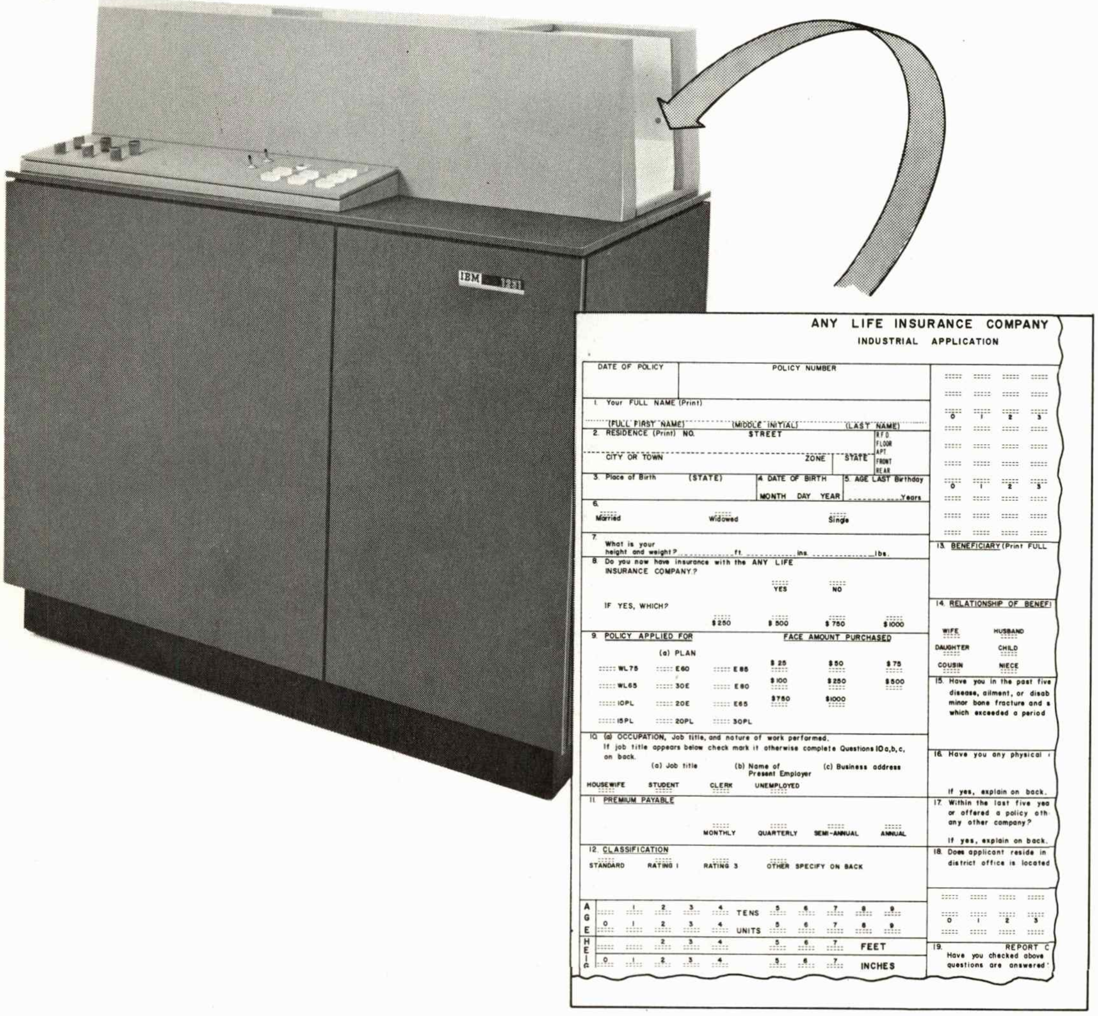
Applications for the 1231 are in payroll, order entry, accounts payable, inventory control, sales analysis, general ledger work, and many others in business, government, and institutions.

As many as four 1231's may be attached to a system.

IBM 1285 Optical Reader

The IBM 1285 Optical Reader can be connected to a channel for the direct reading into the system of numeric and certain other characters printed on journal rolls of paper (Figure 47).

The journal rolls are prepared mainly by cash registers and adding machines; bypassing the transfer of such data to punched cards before computer entry is important for quick sales auditing, inventory control, retailing management decision-making, and many other elements in volume merchandising.



ANY LIFE INSURANCE COMPANY
INDUSTRIAL APPLICATION

DATE OF POLICY
POLICY NUMBER

1. Your FULL NAME (Print)
(FULL FIRST NAME) (MIDDLE INITIAL) (LAST NAME)

2. RESIDENCE (Print) NO. STREET
CITY OR TOWN ZONE STATE
RFD FLOOR APT FRONT REAR

3. Place of Birth (STATE)

4. DATE OF BIRTH
MONTH DAY YEAR

5. AGE LAST Birthday
__________ Years

6. ☐ Married ☐ Widowed ☐ Single

7. What is your height and weight? __________ ft. __________ ins. __________ lbs.

8. Do you now have insurance with the ANY LIFE INSURANCE COMPANY?
☐ YES ☐ NO
IF YES, WHICH?
☐ $ 250 ☐ $ 500 ☐ $ 750 ☐ $ 1000

9. POLICY APPLIED FOR
(a) PLAN
☐ WL75 ☐ E60 ☐ E85
☐ WL65 ☐ 30E ☐ E80
☐ 10PL ☐ 20E ☐ E65
☐ 15PL ☐ 20PL ☐ 30PL

FACE AMOUNT PURCHASED
☐ $ 25 ☐ $ 50 ☐ $ 75
☐ $ 100 ☐ $ 250 ☐ $ 500
☐ $ 750 ☐ $ 1000

10. (a) OCCUPATION, Job title, and nature of work performed.
If job title appears below check mark it otherwise complete Questions 10 a, b, c, on back.
(a) Job title (b) Name of Present Employer (c) Business address
☐ HOUSEWIFE ☐ STUDENT ☐ CLERK ☐ UNEMPLOYED

11. PREMIUM PAYABLE
☐ MONTHLY ☐ QUARTERLY ☐ SEMI-ANNUAL ☐ ANNUAL

12. CLASSIFICATION
☐ STANDARD ☐ RATING 1 ☐ RATING 3 ☐ OTHER SPECIFY ON BACK

AGE
TENS ☐ ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9
UNITS ☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9

HEIG
FEET ☐ ☐ ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7
INCHES ☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7

☐ 0 ☐ 1 ☐ 2 ☐ 3
☐ 0 ☐ 1 ☐ 2 ☐ 3

13. BENEFICIARY (Print FULL

14. RELATIONSHIP OF BENEFI
☐ WIFE ☐ HUSBAND
☐ DAUGHTER ☐ CHILD
☐ COUSIN ☐ NIECE

15. Have you in the past five disease, ailment, or disab minor bone fracture and s which exceeded a period

16. Have you any physical
If yes, explain on back.

17. Within the last five yea or offered a policy oth any other company?
If yes, explain on back.

18. Does applicant reside in district office is located

☐ 0 ☐ 1 ☐ 2 ☐ 3

19. REPORT C
Have you checked above questions are answered

Figure 46. IBM 1231 Optical Mark Page Reader and Sample Data Sheet

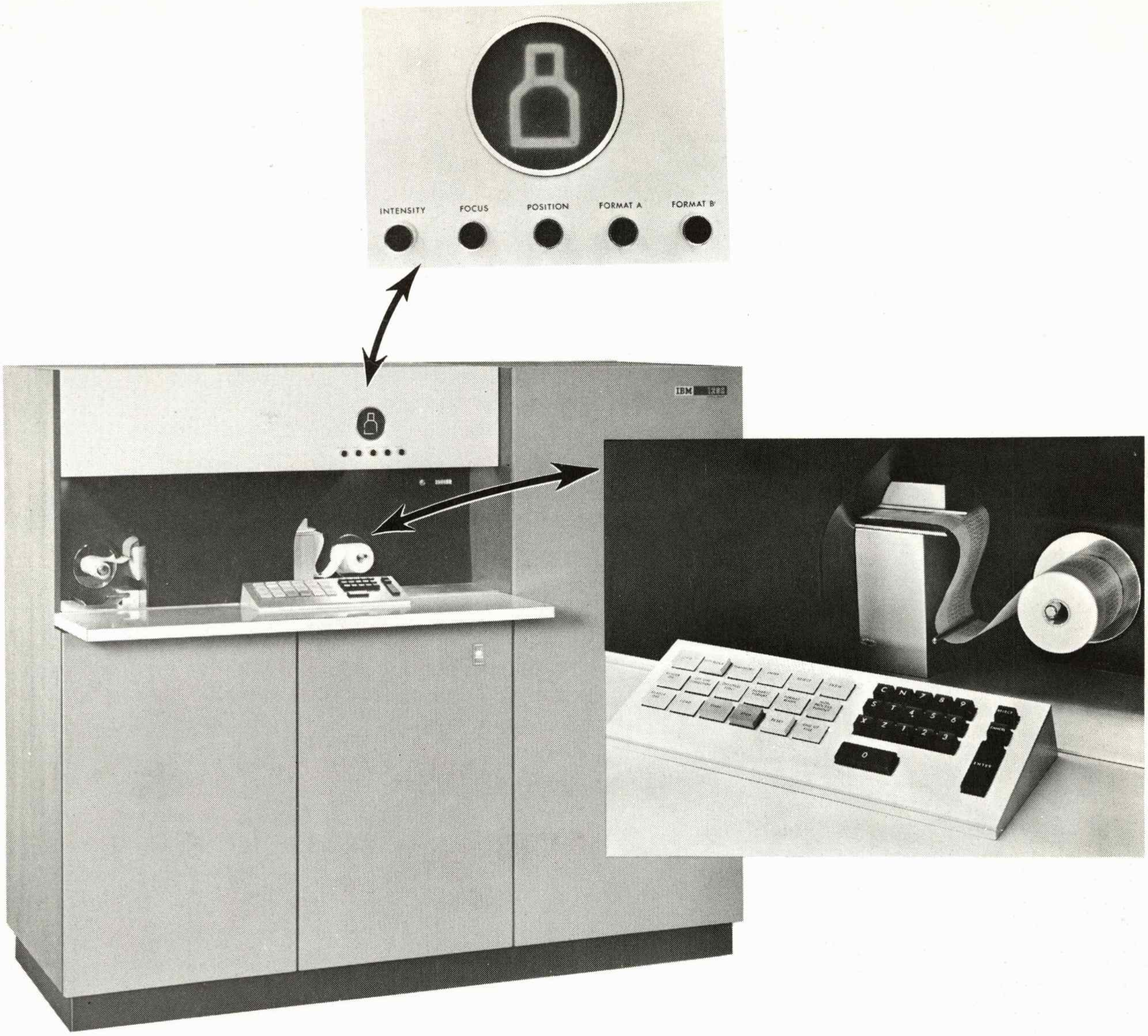


Figure 47. IBM 1285 Optical Reader

The 1285 reads the following characters of the IBM 1428 type font: the digits 0-9, the letters C, N, S, T, X, and Z, and the special symbol ⌿. With a special feature, the reading of either the IBM 1428 font or the NOF font developed by the National Cash Register Company is interchangeable under operator control.

Unreadable characters are automatically rescanned. They can be corrected on-line, or the line containing the unreadable characters may be marked under program control for correction off-line. In the on-line correction mode, the 1285 stops and displays an unreadable character on the display tube. The operator can either correct the character from the keyboard or reject it as unrecognizable. The program may then cause the 1285 to display the full line for review of the rejected character in context, and entry of the full line via the keyboard. Certain unreadable lines may also be entered by this method.

Tape width may be from $1\frac{5}{16}$ to $3\frac{1}{2}$ inches. As many as 32 characters can be read from a single line. Reading speed decreases with the number of characters per line but increases with the number of lines per inch. For example, the reading speed is 2,031 ±5% lines per minute for the IBM 1428 font, or 1,965 ±5% lines per minute for the NOF font, when the following factors are assumed:

1. Ten characters per line
2. Four lines per inch
3. Tape width of 2 inches
4. Distance of 0.2 inch from tape edge to first character

In using the same factors, a continuously-written roll 200 feet long can be read in slightly less than 5 minutes; actual throughput is affected by on-line correction and the user's program.

The operator can control, with a dial setting, so-called descriptive and quantitative fields to be scanned within the lines.

The printed paper is carried by a flat belt past a scan window and wound tightly onto a powered take-up spindle. A self-threading mechanism enables the operator to load a new tape in about 6 seconds. Efficiency in sustaining 1285 throughput is furthered if short rolls, down to the minimum acceptable length of 36 inches, can be spliced together to make up a length near the maximum of 200 feet.

As many as eight 1285's can be used simultaneously with a System/360.

Assistance is offered by IBM to evaluate printing, paper, etc., to produce acceptable 1285 input.

IBM 1287 Optical Reader Models 1 and 2

The IBM 1287 Optical Reader (Figure 48) can be attached to a System/360 channel for the direct reading of source data, whether:

1. Machine-printed and handwritten on card or paper documents such as retail sales checks, inventory lists, toll tickets, utility stubs, and customer order forms.
2. Printed on paper tapes such as those prepared by cash registers and adding machines.

Model 1 can read as many as 24 lines of printed data, at up to 88 characters per line, from each paper or card document (cut form). Model 2, in addition to performing this and all other functions of which Model 1 is capable, can read as many as 38 characters per line from continuous rolls of paper (journal rolls). The design of the machine permits easy changeover, for the Model 2, from documents to journal rolls or vice versa in a matter of seconds. The rolls are automatically threaded.

Characters Recognized

When either model is equipped with the numeric handwriting special feature, it can read the handwritten digits 0-9 and letters C, S, T, X, and Z from cut-form documents. The characters may have been printed with ordinary No. 2 pencils or with mechanical pencils loaded with HB fine line lead. (In addition, certain numbers preprinted on the forms can be read.)

The machine-printed data recognized on cut forms are the digits 0-9 and letters C, N, S, T, X, and Z printed in the IBM 1428 font by high-speed (1403) printers, IBM Selectric® typewriters, etc. Alternatively, 0-9 and three special symbols called "hook," "fork," and "chair" can be read when printed in the American Standard Character Set for Optical Recognition (ASCSOCR) font. (This font can be printed by an IBM Selectric typewriter or its equivalent.) When either font is used, a special preprinted vertical field-mark symbol can also be read. With a special feature, and if the 1428 and ASCSOCR fonts are separated in pre-identified fields, both fonts can be read from the same document under program control.

On journal rolls, the printed digits 0-9 and characters C, N, S, T, X, Z, and ≠ (slash-dash) may be read in the 1428 font. With a special feature, 0-9 and six special symbols may be read in the NOF font developed by the National Cash Register Company, and the reading of either font may be selected by the operator.

A special feature also permits reading characters imprinted on cut-form documents by credit plate imprinters in the Selfchek 7B font developed by the Farrington Manufacturing Company. Another, the optical mark reading feature, permits the reading of vertical, diagonal, or horizontal marks properly made with a No. 2 pencil.

Under program control, variable-length fields may be read in any sequence. The fields may contain machine-printed, typewritten, credit-card imprinted, or (with the special feature) handwritten characters, oriented either vertically or horizontally, on the same document. For example, hand-pencilled merchandise transactions, credit-card imprinted customer account numbers, and preprinted serial numbers can be read from the same source document in one pass through the 1287. The program directs the optical scanning beam to one field at a time. Information is scanned from right to left (units to high-order position) and fed serially, a character at a time, to the channel.

Unreadable characters are automatically rescanned. They may be either displayed on the cathode-ray tube under selective program control for on-line correction from the operator keyboard, or sent to the CPU as @'s (at signs) for programmed correction or reconstruction.

In journal-roll reading, the operator can control the fields to be scanned by setting a dial. Under program control, unreadable characters can either be corrected on-line by the operator from the keyboard, or the lines containing unreadable characters are marked for off-line correction later.

Document Sizes and Flow

The 1287 has an input hopper with a capacity for a 12-inch stack of documents and three output stackers, each holding 4 inches of documents. Documents are fed one at a time under program control to the read station, where each is held stationary while it is scanned and read by the 1287's flying-spot scanner. The document remains in the read station until the program sends it to one of three pockets—one of which (R) is normally reserved for documents containing unreadable characters. Documents can be

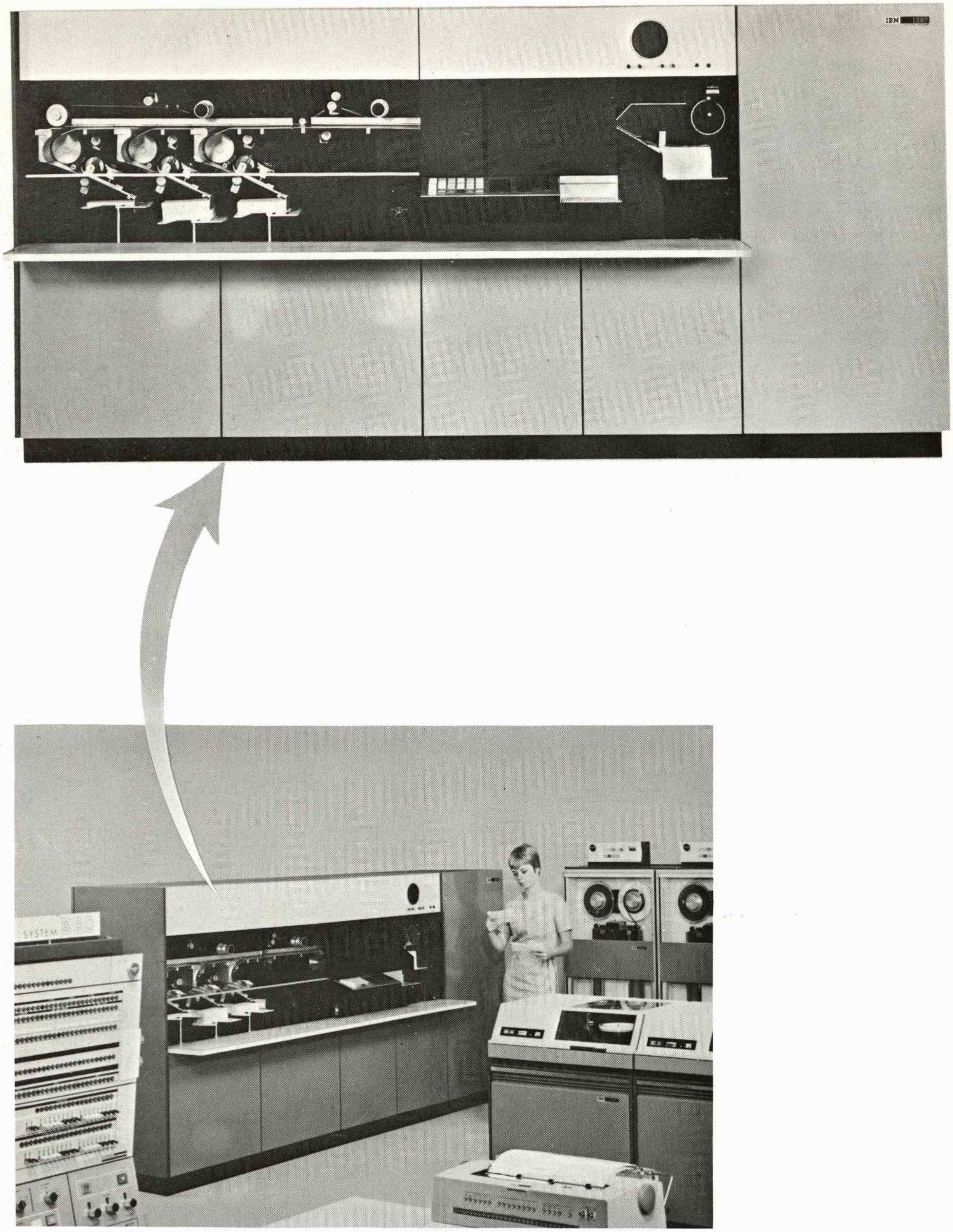


Figure 48. IBM 1287 Optical Reader Model 2

made to overflow between the other two stackers (A and B) to postpone stopping the machine. All documents are counted.

Documents can range in size from 2.25 by 3 inches to 5.91 by 9 inches. The journal rolls read by Model 2 can be from 1⁵⁄₁₆ to 4½ inches in width and from 3 to 200 feet in length.

Speeds

Cut-form document throughput depends on the document size, the number of characters and fields to be read, the type of data (machine-printed, handwritten, pencilled marks), the use of on-line correction, and the program. The typical throughput ranges from less than 100 documents per minute for a 6-inch long document containing 50 fields of handwritten characters to about 600 documents per minute for a 3-inch long document containing one field of 20 machine-printed characters. (For handwritten characters, the 1287 uses curve-following logic: the flying spot of light, when it encounters any part of the character, spirals around it before moving on.)

Journal roll throughput depends on the number of characters per line, the number of lines per inch, and (less importantly) tape width and the clear space between the tape edge and the first character encountered.

Journal roll reading speed (like document reading speed) must be calculated from a formula; it decreases with the number of characters per line and the less important factors, but increases with the number of lines per inch. It is slightly faster than that of the 1285: 2,373 ±5% lines per minute for the 1428 font and 2,283 ±5% for the NOF font, with the same factors as used for the 1285: ten characters per inch, four lines per inch, tape width of 2 inches, and 0.2 inch from tape edge to first character.

Throughput is affected by on-line correction and the user's program. Rescan and line marking of lines containing unreadable characters do not appreciably reduce throughput.

As many as eight 1287 Models 1 and 2 (in any combination) can be used simultaneously with a System/360.

Assistance is offered by IBM to evaluate printing, paper, etc., to produce acceptable 1287 input.

IBM 1418 Optical Character Reader Models 1-3; IBM 1428 Alphameric Optical Reader Models 1-3

Like other optical and magnetic character readers previously described, the IBM 1418 Optical Character Reader (Figure 49) or IBM 1428 Alphameric Optical Reader (Figure 50) can read data directly from a source document, thus removing the necessity of transcribing its data for entry into the system. The documents read by the 1418 or 1428 are prepared mainly by the IBM 1403 (most models) and by electric typewriters. The printing devices must be equipped with one of the type styles designated for 1418 or 1428 input.

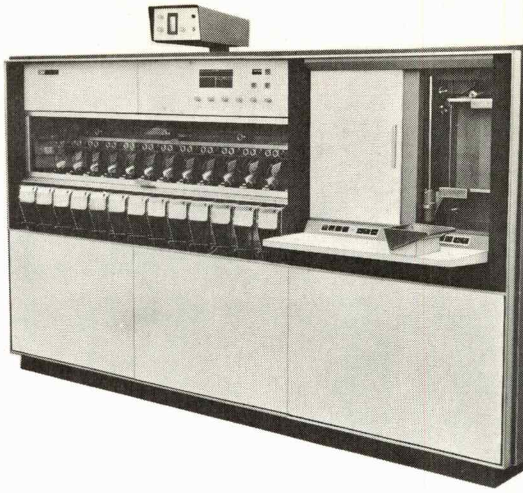


Figure 49. IBM 1418 Optical Character Reader

The 1418 and 1428 differ mainly in that the 1418 reads numeric data, and the 1428 reads alphameric data.

The 1418 reads the special characters – ⌑ and the digits 0-9. The 1428 reads the upper-case letters A-Z, the special characters $ - . , * / and the digits 0-9. Either machine reads a solid vertical line preprinted on the forms. Characters can be printed 10 or fewer per inch; adjacent fields can be printed at a different pitch (number of characters per inch).

Model 1 of either machine has three stackers and can select the documents according to three classes or general categories. Model 2, with thirteen stackers, can sort documents numerically in addition to sorting by class. Model 3, which is similar in appearance and

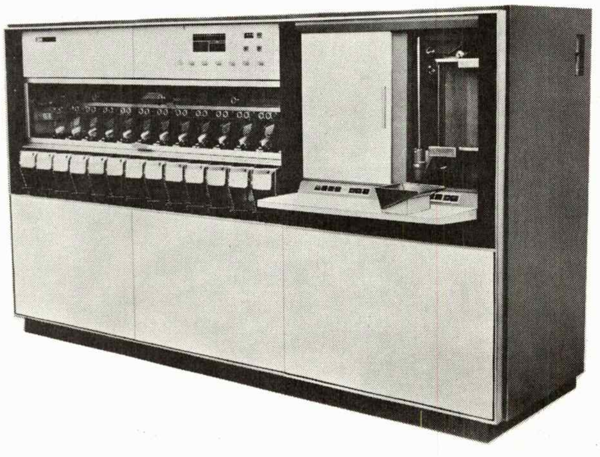


Figure 50. IBM 1428 Alphameric Optical Reader

operation to Model 1, handles a broader range of document sizes and thicknesses than either Model 1 or 2 and is particularly suitable for cash-accounting applications in which a small stub is returned with a payment. All models have a 12-inch hopper, a document counter, and a character reading station.

The speed for all models, in terms of documents per minute, has the relationships to document width that are indicated in Figure 51.

Mark-reading special features permit reading prescribed pen or pencil marks directly into the system. In place of these, an additional read station special feature permits the reading of information from any of two lines on a document in one pass.

Only one 1418, or one 1428, may be attached per system.

I/O Equipment Pertaining to USASCII

The following input/output equipment will read and write the U.S.A. Standard Code for Information Interchange (USASCII). As a matter of convenient identification, USASCII-7 is a designation given to this seven-bit code; and USASCII-8 is a designation given to an eight-bit representation of USASCII-7.

Magnetic Tape: The IBM 2401 and 2415 magnetic tape units and IBM 7340 Hypertape units are code insensitive; hence, the 2401 and 2415 units can read and write USASCII-8 at 800 or 1,600 bytes per inch with an interblock gap of 0.6 inch; and Hypertape can read and write USASCII-8 at 1,511 bytes per inch with an interblock gap of 0.45 inch or at 3,022 bytes per inch with an interblock gap of 0.38 inch.

	Models 1 and 2		Model 3		
	Vertical Range	Horizontal Range	Vertical Range, Nominal	Horizontal Range, Nominal	
Document Size, Inches 1418 or 1428	$2\frac{3}{4}$ - $3\frac{2}{3}$	$5\frac{7}{8}$ - $8\frac{3}{4}$	$2\frac{1}{3}$ - $4\frac{7}{32}$	3 - $8\frac{3}{4}$	
				Subrange 3 - $5\frac{1}{2}$	Subrange $5\frac{7}{8}$ - $8\frac{3}{4}$
Speed, Documents Per Minute					
1418		420-300		420-375	420-300
1428		400-288		400-360	400-288

Figure 51. IBM 1418 and 1428 Document Reading Speeds

Direct Access Devices such as disk files are also code insensitive and can therefore read or write USASCII-8.

Paper Tape: The IBM 2671 Paper Tape Reader and 2822 Paper Tape Reader Control will read the proposed U.S.A. Standard Perforated Tape Code for Information Interchange (USASCII-7).

Transmission: When the IBM 2848 Display Control (for IBM 2260 Display Station) is installed at a location remote from the system and is equipped with an appropriate data set adapter, it can transmit and receive USASCII-7.

Attachment of Devices

Figure 52 shows attachment data for all devices described in this section. (For attachment data pertinent to those devices or subsystems used only for teleprocessing, data acquisition, or process control as described in the following section, see Figure 53.)

Device Name and Number, With Exclusive Models			Attaches to Channel Via	Control-Unit Type	Attaches to System/360 Model Via Channel Types							
No.	Model	Name			30	40	44	50	65	67	75	91
1051	1	Control Unit	****	Shared Path	See 1052-3, 1053-1							
1051	N1	Control Unit	****	Shared Path	See 1052-5, 6, 8, 1053-1							
1052	3	Printer-Keyboard	1051-1	---	W	--	--	--	--	--	--	--
1052	5	Printer-Keyboard	1051-N1	---	W	--	--	--	--	--	--	--
1052	6	Printer-Keyboard	1051-N1	---	W	--	--	--	--	--	--	--
1052	7	Printer-Keyboard *	CPU Adapter or 2150	Single Path ---	-- --	M --	M,H1 --	M M,S	M,S M,S	M,S M,S	-- M,S	-- M,S
1052	8	Printer-Keyboard	1051-N1	---	W	--	--	--	--	--	--	--
1053	1	Printer	1051-1,N1	---	W	--	--	--	--	--	--	--
1053	4	Printer	2848-1-3	---	M,S	M, S	M,H	M,S	M,S,X	M,S	M,S,X	M,S,X
1231	N1	Optical Mark Page Reader	---	Single Path	M,S	M,S	--	M,S	M,S,X	--	--	--
1285		Optical Reader	---	Single Path	M,Sf	M,Sf	--	M,Sf	M,S,X	--	--	--
1287	1,2	Optical Reader	---	Single Path	M,Sf	M,Sf	--	M,Sf	--	--	--	--
1403	2,N1	Printer	2821-1,2,3,5	---	M,S	M,S	M,H	M,S	M,S,X	M	M,S,X	M,S,X
1403	3	Printer	2821-1,2,3,5	---	M,S	M,S	M,H	M,S	M,S,X	--	M,S,X	--
1403	7	Printer	2821-1,2,3,5	---	M,S	M,S	M,H	M,S	M,S,X	--	M,S,X	M,S,X
1404	2	Printer	2821-4	---	M,S	M,S	--	M,S	--	--	--	--
1412		Magnetic Character Reader	---	Single Path	M	--	--	--	--	--	--	--
1418	1-3	Optical Character Reader	---	Single Path	M,S	M,S	--	M,S	M,S,X	--	--	--
1419		Magnetic Character Reader	---	Single Path	M,S	M,S	--	M,S	M,S,X	--	--	--
1428	1-3	Alphameric Optical Reader	---	Single Path	M,S	M,S	--	M,S	M,S,X	--	--	--
1442	N1	Card Read Punch	---	Single Path	M,S	M,S	M,H	M,S	M,S,X	--	M,S,X	M,S,X
1442	N2	Card Punch	---	Single Path	M,S	M,S	M,H	M,S	M,S,X	--	M,S,X	M,S,X
1443	N1	Printer	---	Single Path	M,S	M,S	M,H	M,S	M,S,X	--	M,S,X	M,S,X
1445	N1	Printer	---	Single Path	M,S	--	--	--	--	--	--	--
2150		Console	---	Single Path	--	--	--	M,S	M,S	M	M,S	M,S
2250	1	Display Unit	---	Single Path	M,S	M,S	M,H	M,S	S,X	S	S,X	S,X
2250	3	Display Unit	2840-2	---	M,S	M,S	M,H	M,S	S,X	S	S,X	S,X
2260		Display Station	2848-1-3	---	M,S	M,S	M,H	M,S	M,S,X	M,S	M,S,X	M,S,X
2301		Drum Storage	2820	---	--	--	--	--	S	S	S	S
2302	3,4	Disk Storage	2841	---	M°,S°	M,S	--	M,S	S	--	S	--
2303		Drum Storage	2841	---	--	S1	--	S	S	--	S	S
2311		Disk Storage Drive	2841	---	M°,S°	M,S	M,H	M,S	S	S	S	S
2314		Direct Access Storage Facility	2844°°	Shared Path	S1°	S1	--	S	S	S	S	S
2321		Data Cell Drive	2841	---	M°,S°	M,S	--	M,S	S,X	S	S,X	S,X
2401	1-3	Magnetic Tape Unit	2803-1,2 or 2804-1,2**	---	M,S	M,S	M,H	M,S	S,X	S,X	S,X	S,X
2401	4,5	Magnetic Tape Unit	2803-2 or 2804-2	---	M,S	M,S	M,H	M,S	S,X	--	S,X	S,X
2401	6	Magnetic Tape Unit	2803-2 or 2804-2	---	S	S	H	M,S	S,X	--	S,X	S,X
2415	1-6	Magnetic Tape Unit and Control	---	Shared Path	M,S	M,S	--	M,S	S,X	--	S,X	S,X
2501	B1,B2	Card Reader	---	Single Path	M,S	M,S	M,H	M,S	M,S,X	--	M,S,X	M,S,X
2520	B1	Card Read Punch	---	Single Path	M,S	M,S	M,H	M,S	M,S,X	--	M,S,X	M,S,X
2520	B2,B3	Card Punch	---	Single Path	M,S	M,S	M,H	M,S	M,S,X	--	M,S,X	M,S,X
2540		Card Read Punch	2821-1,4,5	---	M,S	M,S	M,H	M,S	M,S,X	M	M,S,X	M,S,X
2671		Paper Tape Reader	2822	---	M,S	M,S	M,H	M,S	--	M	--	--

Figure 52. Attachment Data (Part 1 of 2)

Device Name and Number, With Exclusive Models			Attaches to Channel Via		Attaches to System/360 Model Via Channel Types							
No.	Model	Name		Control-Unit Type	30	40	44	50	65	67	75	91
2802		Hypertape Control	---	Shared Path	See 7340-3							
2803	1	Tape Control	---	Shared Path	See 2401-1-3							
2803	2	Tape Control	---	Shared Path	See 2401-1-6							
2804	1	Tape Control	---	Shared Path	See 2401-1-3							
2804	2	Tape Control	---	Shared Path	See 2401-1-6							
2814	1-3	Switching Unit	---	---	See footnote #							
2816	1	Switching Unit	2803-1,2	---	See 2401-1-6							
2816	2	Switching Unit	2802	---	See 7340-3							
2820		Storage Control	---	Shared Path	See 2301							
2821	1,5	Control Unit	---	Multipath	See 1403-2,3,7, N1, 2540							
2821	2	Control Unit	---	Single Path	See 1403-2,3,7, N1							
2821	3	Control Unit	---	Multipath	See 1403-2,3,7, N1							
2821	4	Control Unit	---	Multipath	See 1404-2, 2540							
2822		Paper Tape Reader Control	---	Single Path	See 2671							
2840	2	Display Control	---	Shared Path	See 2250-3							
2841		Storage Control	---	Shared Path	See 2302-3,4, 2303, 2311, 2321							
2844		Auxiliary Storage Control	---	Shared Path	See 2314							
2848	1-3	Display Control	---	Shared Path	See 2260							
7340	3	Hypertape	2802	---	M%,S%	M%,S	--	M%,S	S	--	S	S
*** Console Printer-Keyboard			CPU Adapter	Single Path	--	--	M,H1	--	--	--	--	--
*** Display Console			---	Single Path	--	--	--	--	--	--	--	S,X
*** Single-Disk Storage Drive			CPU Adapter	Shared Path	--	--	M,H1	--	--	--	--	--

CHANNEL SYMBOLS

M	= Multiplexer channel (including basic channel of 2870 but not high-speed multiplexer channel).
H	= High-speed multiplexer channel.
S	= Selector channel.
X	= Selector subchannel on 2870.
S1	= First selector channel.
S1°	= First selector channel, also restricted attachment of other devices on second selector channel. (No 2314 can be attached if CPU uses 2-microsecond storage; see Figure 2).
Sf	= Attachment to selector channel requires a special feature.
H1	= First high-speed multiplexer channel.
M°,S°	= Only S1 when a 2314 or 2844 is also attached, otherwise M or S.
M%,S%	= Operation of 7340 is only at its "low" rate of 170,000 bytes per second.
W	= Without channel.

FOOTNOTES

* In Model 44, as "Console Printer-Keyboard."

** In Model 67, only 2803-1.

*** Standard feature.

**** Attaches without using a channel.

Two-channel switching unit for Model 67 only. 2814-1 for 2250-1, 2814-2 for 2840-2, 2814-3 for 2848-1-3.

∞ The 2314 contains its own control, but the 2844 may be attached as a second control.

Single Path = Only one device is associated with the control unit.

Shared Path = Only one attached device at a time is in a data-transferring operation. When attached to M on Models 30-50, a shared subchannel may be used; where more than 16 devices can be attached (e.g., the 2848-3), a second shared subchannel is used. Where H or X is specified, the equivalent sharing capability of such subchannels is used.

Multipath = Attached devices are in data-transferring operations simultaneously. When attached to M, each device requires one nonshared subchannel.

Figure 52. Attachment Data (Part 2 of 2)

Terminal	System/360 Control Unit #	System/360 Model						
		30	40	44	50	65	67	75/91
1030 Data Collection System								
1050 Data Communication System	2701	S,M	S,M	M,H	S,M	S,M,X	S,M,X	S,M,X
1060 Data Communication System								
1070 Process Communication System	2702	M	M	M	M	M	M	M
2740 Communications Terminal								
2741 Communications Terminal	2703	M	M	--	M	M	--	M
2711 Line Adapter Unit	2702	M	M	M	M	M	M	M
2712 Remote Multiplexer	2703	M	M	--	M	M	--	M
1092 Programmed Keyboard	7770,7772	M	M	--	M	M	--	M
1093 Programmed Keyboard	2701 (via 1051)	S,M	S,M	M,H	S,M	S,M,X	S,M,X	S,M,X
	2702 (via 1051)	M	M	M	M	M	M	M
	2703 (via 1051)	M	M	--	M	M	--	M
1001 Data Transmission Terminal	7770,7772	M	M	--	M	M	--	M
1800 Data Acquisition and Control System	1827 System/360 Adapter	S,M S,M	S,M S,M	M,H M,H	S,M S,M	-- --	-- --	-- --

S = Selector Channel
M = Multiplexer Channel
H = High-speed Multiplexer Channel (Model 44 only)
X = Selector Subchannel (Special feature for 2870)

# All control units listed are multipath except those for the 1800 system, which are single path.

Figure 53. Attachment Data for Teleprocessing, Data Acquisition, and Process Control Terminals

Teleprocessing, Data Acquisition, and Process Control

During the early design stages of System/360 the system designers set as their goal the creation of a truly general-purpose system, one that would be able to operate in many diverse environments. One of their major considerations was that the system would have to serve as the data processing complex within a larger teleprocessing system. (See Figure 54.)

IBM's past experience with real-time and teleprocessing systems indicated that there are two major differences between teleprocessing systems and the more familiar batch processing systems: in batch processing input is scheduled, while teleprocessing input is unscheduled; batch processing is usually serial, while teleprocessing is random. To incorporate the ability to service these two teleprocessing characteristics into a system that would probably be employed mostly for batch processing, the System/360 designers had to create new equipment and new programming conventions.

As an example of how a teleprocessing system functions, suppose that a clerk in an insurance company's branch office receives a telephone call asking for information about an insured's account. Asking the caller to hold the line, the clerk enters the information request into a terminal, and the request is sent over a communications line to the System/360 at the insurance company's main office. When the request reaches the computer, several things happen. The computer interrupts processing whatever job it is working on (perhaps the payroll is being run) and saves all necessary data and instructions so that it can resume processing at exactly the point in the program it had reached before it was interrupted. As the information is received over the communications lines, the communications module in the control program converts the data into machine language, stores it in a buffer area, and checks to see that it was transmitted correctly.

The nature of the request may dictate that a number of different operations must be performed. To process the request, the teleprocessing program directs the System/360 to run through the appropriate policy file and bring the insured's record from storage. The program then searches the record for the information requested and sends it out over the communications lines to the clerk who originated the request. The clerk reads the information as it is typed out at his terminal and relays the information to the policyholder or adjuster waiting on the telephone. Back at the main office, the control program has returned the System/360 to its status prior to the interruption by the inquiry, and the computer has resumed processing the payroll program.

Requirements of a Teleprocessing System

A careful examination of the above example reveals that any teleprocessing system must meet certain requirements. System/360 was designed to respond to all of these requirements without sacrificing its efficient performance of the ordinary batch data processing needs of science and industry.

Transmission Control Capability

The system may be servicing many locations, some on common communications lines and some on separate lines. Equipment and programming are therefore required to handle the multiple inputs arriving in unscheduled fashion into the System/360.

Program Switching

On a single transaction, the control program initiates several switches among the various programs; therefore, the processing unit must be designed to accomplish very rapid program switching.

Program Relocation

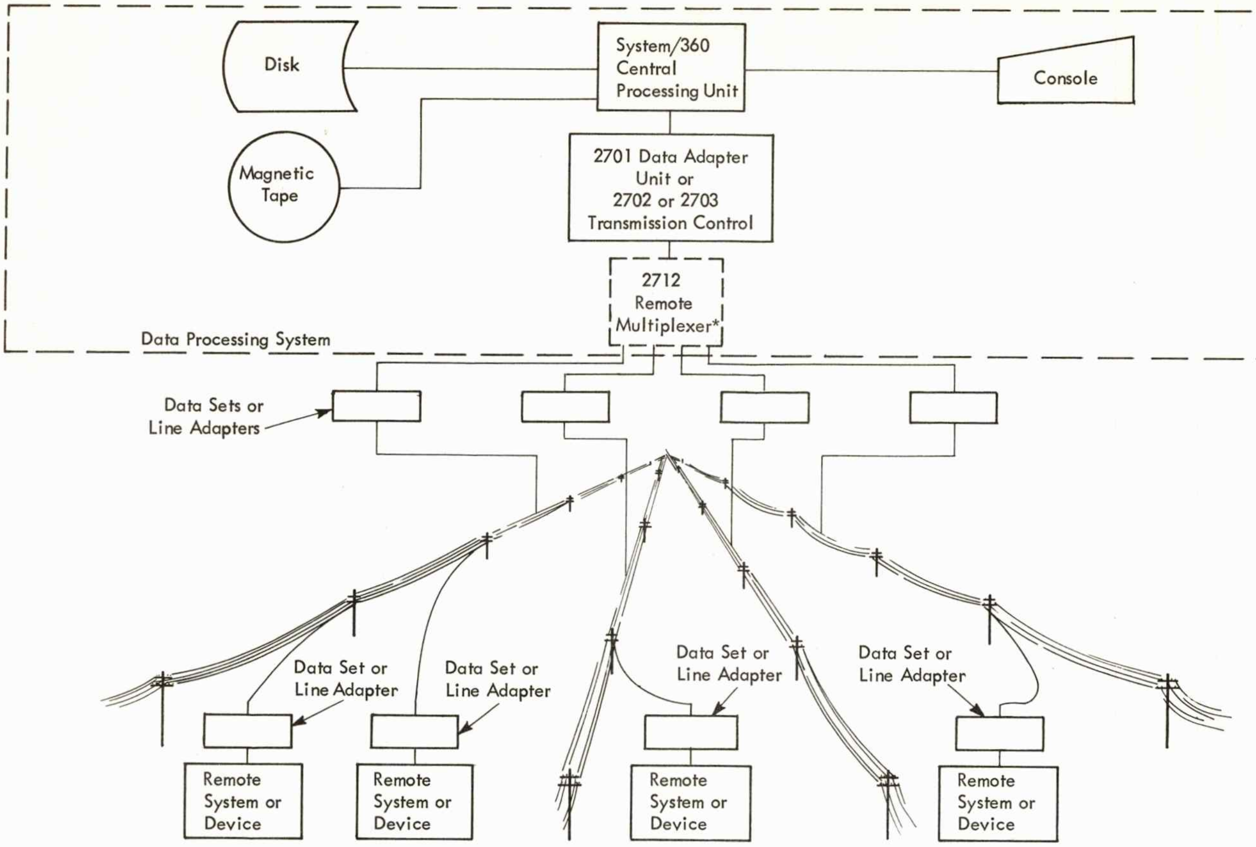
The processing unit must also have the ability to dynamically relocate programs in storage during normal processing, because many different types of transactions may necessitate bringing a program from peripheral storage into a location in main storage for which the program was not originally assembled.

Storage Protection

With multiple programs residing in the system at one time and with constant program switching and relocation taking place, it is imperative that there be a facility available that can prevent one program from changing another program's instructions and data.

Transmission—Directions, Grades, and Modes

A circuit, channel, or line is a path for electrical transmission between two or more terminals. Basically, IBM equipment can operate over three types of circuits: simplex, half-duplex, and full-duplex (or duplex).



* Optional Device. Attachable to 2702 or 2703.

Figure 54. System/360 as a Teleprocessing System

These circuit names describe only directional capability.

Simplex Circuits can carry data in only one direction.

Half-Duplex Circuits can carry data in two directions but in only one direction at a time.

Full-Duplex Circuits can carry data in two directions at the same time.

A network can consist of any combination of these circuits according to application requirements.

Grades

The three types of circuits are each graded on their transmission rates in terms of characters per second, bits per second, or words per minute. There are four circuit grades: broad band, voice grade, subvoice grade, and telegraph. However, there are no rigid limitations separating one grade from another.

Broad Band Circuits transmit data at a rate that is limited only by the band width available: microwave, radio signals, or coaxial cables are often used to carry data rapidly from point to point.

Voice Grade Circuits can handle about 2,400 bits per second. A voice grade circuit can be divided into several smaller circuits, each suitable for subvoice or telegraph communications.

Subvoice Grade Circuits are usually considered to be those operating at a transmission rate less than 600 bits per second.

Telegraph Circuits operate at speeds ranging from approximately 45 to 75 bits per second.

Modes

Information can be transmitted over the various types and grades of circuits by three different modes of transmission: asynchronous (also called serial start/stop), synchronous, and parallel.

Asynchronous Transmission requires the use of start and stop bits to designate the beginning and ending of characters.

Synchronous Transmission eliminates the need for start and stop bits; a special pattern of bits is sent periodically to keep the transmitter and receiver operating in unison. The bit pattern is generated automatically and sent as required by the system.

Parallel Transmission allows all bits of a character to be transmitted simultaneously by providing one circuit for each bit in the code structure.

Most often a user obtains his communications lines from a communications common carrier. The common carrier leases him a private line for his exclusive use or connects him with the telephone network available to the public. A user can also purchase and maintain his own communications facilities, but these must be purchased from suppliers other than common carriers. There are numerous government regulations concerning the connection of privately owned communications facilities to those owned and maintained by common carriers.

Terminal Connections to Communications Lines

Throughout this section of the System Summary the word "terminal" refers to a machine or group of machines capable of generating and/or receiving signals transmitted over a communications line. Within this definition a terminal may range from a data processing system, such as System/360, to a single device, such as an IBM 1092 Programmed Keyboard. A terminal may be connected to another terminal by a point-to-point or by a multipoint line. A point-to-point (private) line connects a single terminal to another single terminal. A multipoint line connects more than two terminals. On circuits with little traffic, its use often results in a cost saving. Terminals sharing the same line may or may not have the ability to communicate with each other.

Data Sets

A data set is a modulation-demodulation device (modem) used to connect business machines to communications lines. Modulation is the conversion of digital signals from the business machine to audio frequency signals for transmission over communications lines. Demodulation reconverts the information for machine use. One data set is required at each interface between the communications facilities and the data processing equipment. The data set may be supplied by a communications common carrier or, under certain circumstances, by IBM. An IBM-supplied data set is called a "line adapter." Because of legal restrictions, IBM line adapters can only be used on customer owned transmission lines or on lines leased from common carriers. Line adapters and common-carrier data sets cannot be mixed within the same network.

Teleprocessing Systems and Devices

The following teleprocessing systems and devices are attachable on-line to System/360. Most are attachable through the 2701 Data Adapter Unit, the 2702 or 2703 Transmission Control, or the 2712 Remote Multiplexer. The possible connections to the various channels on the System/360 models are listed in Figure 53. For more information consult the *IBM Teleprocessing System Summary,* Form A24-3090, which contains brief descriptions of all IBM teleprocessing terminals, and the *IBM Teleprocessing Bibliography,* Form A24-3089, which contains a complete list of all publications pertaining to IBM teleprocessing equipment.

Transmission Control

IBM 2701 Data Adapter Unit
IBM 2702 Transmission Control
IBM 2703 Transmission Control
IBM 2712 Remote Multiplexer

Terminals

IBM 1001 Data Transmission Terminal
IBM 1092 Programmed Keyboard
IBM 1093 Programmed Keyboard
IBM 2740 Communications Terminal
IBM 2741 Communications Terminal

Systems

IBM 1030 Data Collection System
IBM 1050 Data Communication System
IBM 1060 Data Communication System
IBM 1070 Process Communication System

Line Adapter Unit

IBM 2711 Line Adapter Unit

Audio Communications

IBM 7770 Audio Response Unit Model 3
IBM 7772 Audio Response Unit

Transmission Control

Just as local cable-connected input/output devices require a control unit to interface their attachment to the system channels, devices that transmit over communications lines similarly require a control unit to perform interface matching, character assembly, and transmission control. In System/360 teleprocessing configurations these functions are usually performed by the IBM 2701 Data Adapter Unit, the IBM 2702 Transmission Control, and the IBM 2703 Transmission Control.

IBM 2701 Data Adapter Unit

The IBM 2701 Data Adapter Unit (Figure 55) provides for the on-line connection to System/360 of a variety of local and remote systems and devices. The connection can occur over private or common-carrier communications facilities (Figure 56). Among the systems and devices that can be atached via the 2701 are:

IBM 1030 Data Collection System
IBM 1050 Data Communication System
IBM 1060 Data Communication System
IBM 1070 Process Communication System
Telegraph Terminals
Data Acquisition and Control Equipment
Other System/360's Equipped with 2701's

Eight 2701's can be attached to a System/360 channel, each occupying one control unit position. With the second channel interface special feature, the 2701 can be attached to any other channel on the same processing unit or to a channel on another processing unit. This means that different terminal devices on the 2701 can operate via separate channels. However, the assignment of terminals to channels is permanent; once a terminal is assigned to a particular channel, it can operate only via that channel.

Each 2701 provides for the attachment of up to four half-duplex (two ways alternately) asynchronous communications lines with line speeds up to 600 bits per second, or up to four (maximum of two operating simultaneously) half-duplex synchronous communications lines with lines speeds up to 40,800 bits per second, or up to four parallel data acquisition devices (word width of 16 to 48 bits). Various combinations of the data communications and data acquisition devices are possible within any given 2701.

All necessary bit-byte and word-byte conversions, interface matching, and data control for the attachment of specific terminal devices is accomplished by the functional sections of the 2701. Many optional features are available for further refinement in meeting user requirements.

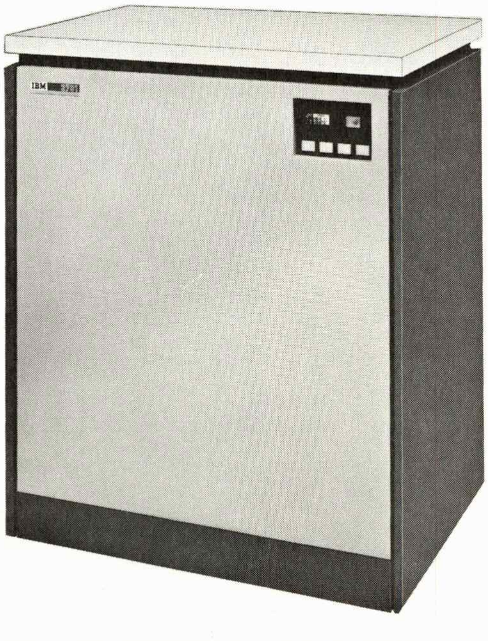


Figure 55. IBM 2701 Data Adapter Unit

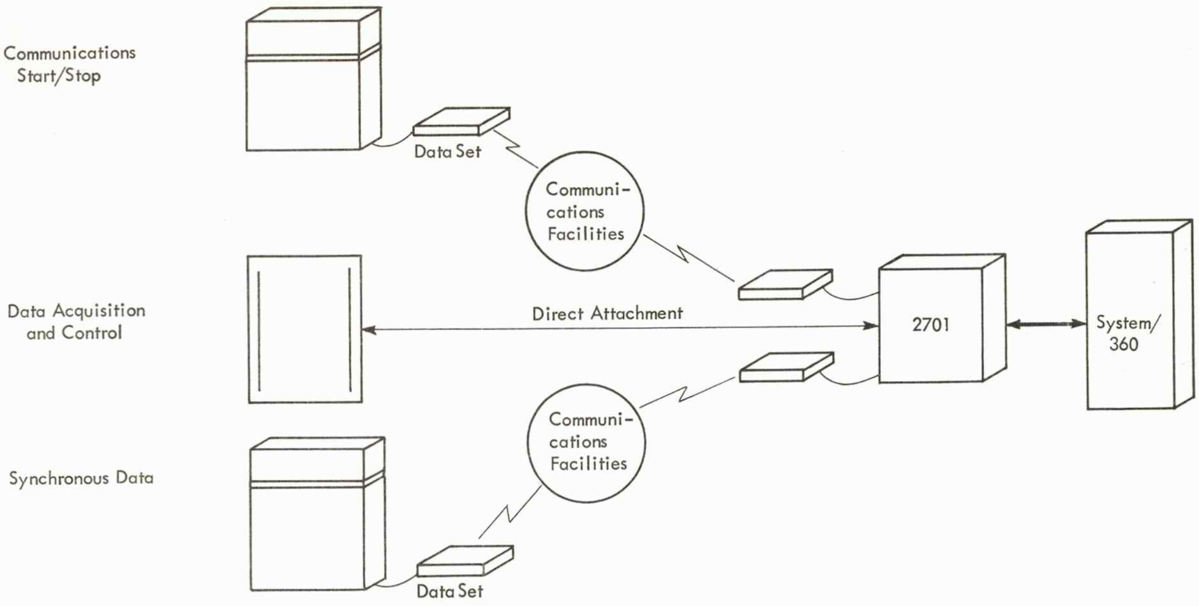

Communications Start/Stop
Data Set
Communi-cations Facilities
Data Acquisition and Control
Direct Attachment
2701
System/360
Synchronous Data
Communi-cations Facilities
Data Set

Figure 56. 2701 in a System Environment

Functional Sections

The basic IBM 2701 Data Adapter Unit consists of two functional sections: the transmission interface converter (XIC), and the transmission adapter (XA) (Figure 57). The XIC and XA operate as a couple which provides a single complete path for the operation of the terminal devices with the channel. The transmission interface converter is the same for all 2701's, but the transmission adapter in one 2701 may differ from that in another 2701. Different transmission adapters must be chosen to accommodate different types of terminals.

Although the basic 2701 allows for only one XIC-XA couple, three more may be obtained through the 2701's special features.

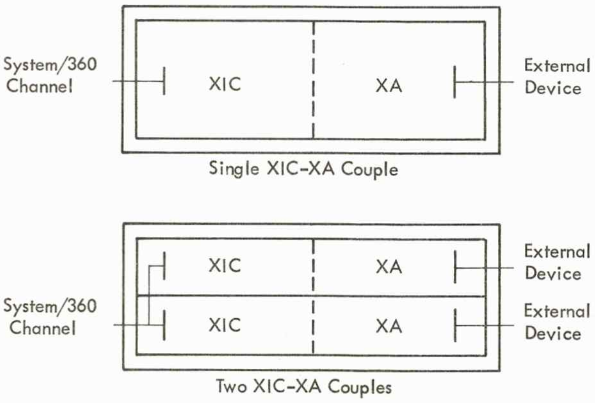


Figure 57. 2701 Functional Sections

Transmission Interface Converter (XIC): The transmission interface converter controls information transfer between a System/360 channel and a transmission adapter of a 2701. When the 2701 is connected to the selector channel, byte transfer is in burst mode; when it is connected to the multiplexer channel, byte transfer is normally in multiplex mode. However, when operating with the multiplexer channel, a manual switch can be set to force burst mode or to allow multiplex mode. In multiplex mode, an XA causes single- or multiple-byte transfers, depending on the type of XA.

Transmission Adapter (XA): The transmission adapter provides for the connection of remote and local devices to the 2701. It contains the circuitry and logic for the control of the terminal device, the buffering of the data flow, the decoding of the program commands, and the connection to and operation with the XIC and the I/O channel.

There are three classifications of transmission adapter used with the 2701: communications-start/stop, communications-synchronous, and data acquisition and control (parallel data adapter). The adapters in each of these classifications operate with terminals that transmit in one of the three modes described under "Transmission Modes."

Special Features

The expansion feature and the expanded capability feature allow the expansion of the basic 2701 (one XIC-XA couple) to as many as four couples. A variety of other features is also available. The *Data Communications and Acquisition Configurator*, Form A22-6824, shows the various features for the 2701 and diagrams the numerous configurations possible with this unit.

IBM 2702 Transmission Control

The IBM 2702 Transmission Control (Figure 58) performs functions similar to those of the IBM 2701 Data Adapter Unit. (See the preceding description.) The 2702 Transmission Control provides for the on-line attachment to System/360 of various asynchronous systems and I/O devices via private or common-carrier transmission facilities. Among the systems and devices that can be attached to System/360 via the 2702 are:

IBM 1030 Data Collection System
IBM 1050 Data Communication System
IBM 1060 Data Communication System
IBM 1070 Process Communication System
IBM 2711 Line Adapter Unit
IBM 2712 Remote Multiplexer
IBM 2740 and 2741 Communications Terminals
Telegraph Terminals

The 2702 Transmission Control occupies one control unit position on a System/360 multiplexer channel. As many as eight 2702's can be attached to any multiplexer channel, and the operation of each is in the multiplex mode. Every attached communications line requires one subchannel.

The 2702 is a modular unit with a variety of features to meet a customer's data communications needs. It is flexible in line capacity, transmission code, and speed. The basic 2702 can have 15 half-duplex lines and operate at speeds up to 180 bits per second for any and all attached communications lines. All lines can operate simultaneously. With special features, the transmission speed of the basic 15 lines can be increased to 600 bits per second, or as many as 16 additional lines operating in start-stop mode with speeds up to 200 bits per second may be added. The two features are mutually exclusive, however.

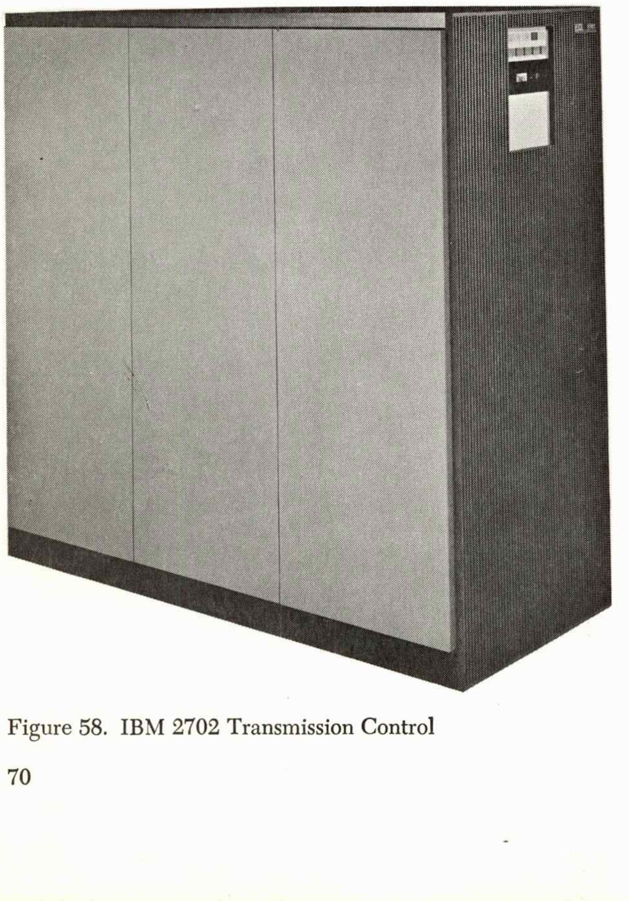


Figure 58. IBM 2702 Transmission Control

Data transmission is serial-by-bit with the terminals and serial-by-byte with the channel. The 2702 converts data bytes from the processing unit into bits for transmission to the terminals and assembles incoming serial data into bytes for transfer to processor storage where messages are assembled.

Functional Sections

The 2702 consists of four functional sections: the interface control section, the common controls and storage section, the terminal controls section, and the line adapter section (Figure 59). These functional sections perform all serializing and deserializing of transmitted characters, data control, and interface matching to common-carrier equipment.

Interface Controls Section provides the facilities for connecting the 2702 to the standard interface used by System/360.

Common Controls and Storage Section accepts commands and data bytes from the interface controls section and performs all functions common to each communications line, such as character assembly and buffering, line time out, and error control.

Terminal Controls Section performs functions associated wtih a given communications terminal, such as character or character sequence recognition and checking of the transmission code. One terminal control may service all attached terminals of the same type. Each 2702 requires at least one terminal control; three may be chosen.

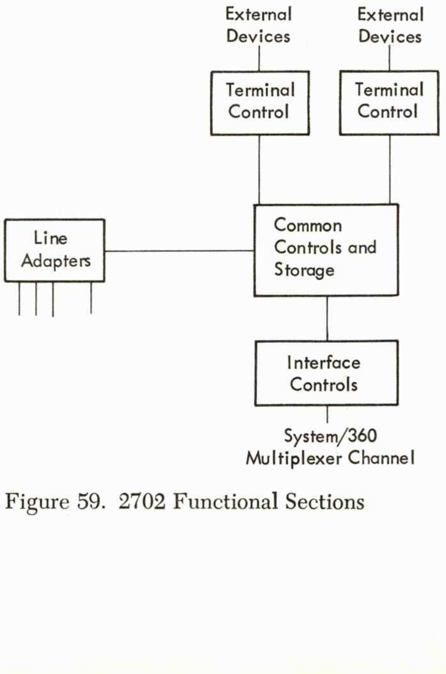


Figure 59. 2702 Functional Sections

Line Adapters Section contains one adapter (modem) for each communications line attached to the 2702. Four types of adapters are available; the choice is generally independent of the type of terminals and dependent upon the communications facility specified.

Data Set Line Adapter: Provides for attachment to common-carrier leased private line or common-carrier switched telephone service.

Telegraph Line Adapter: Provides for attachment to common-carrier leased private line telegraph service.

IBM Line Adapter: Provides for attachment to privately-owned limited distance (up to 8 miles) communications facilities.

2712 Line Adapter: One adapter is required for each line operating with a 2712 Remote Multiplexer.

Special Features

Speed Extension Feature allows the 2702 to operate at speeds up to 600 bits per second when only the basic 15 lines are attached.

31 Line Expansion Feature expands the line-handling capabilities of the 2702 to 31 half-duplex lines operating at a combined speed of 200 bits per second. The 31 Line Expansion Feature and the Speed Extension Feature cannot both be installed on any 2702.

Additional Selective Speed Feature provides for installation of an additional selective speed on terminal controls where more than one speed is available. Without this feature, a terminal control may operate terminals at one speed only.

Automatic Call Feature provides the capability of automatically dialing remote terminals under control of the processor program.

Two Processor Switch Feature attaches one 2702 to the multiplexer channels of two System/360 processing units. The 2702 is switched between the two channels under program control.

IBM 2703 Transmission Control

The IBM 2703 Transmission Control performs functions similar to those of the IBM 2701 Data Adapter Unit and the IBM 2702 Transmission Control. (See the preceding descriptions.) The 2703 Transmission Control directs and controls information flow between System/360 and a variety of remote communications terminals over private and common-carrier transmission facilities. Among the systems and devices that can be connected to System/360 via the 2703 are:

IBM 1030 Data Collection System
IBM 1050 Data Communications System
IBM 1060 Data Communications System
IBM 1070 Process Communications System
IBM 2711 Line Adapter Unit
IBM 2712 Remote Multiplexer
IBM 2740 and 2741 Communications Terminals
Telegraph Terminals

The 2703 Transmission Control occupies one control unit position on a System/360 multiplexer channel. It requires one nonshared multiplexer subchannel for each attached half-duplex line.

The 2703 is flexible in line capacity, transmission code, and speed. The basic unit with appropriate features operates at speeds up to 600 bits per second with eight half-duplex lines attached; up to 64 more half-duplex lines can also operate with the basic unit with no loss of speed. At speeds up to 180 bits per second, the unit can operate with as many as 176 half-duplex lines. Many line-speed combinations are possible; only the system configuration determines the limitation.

The 2703 allows continuous automatic polling of most IBM terminals without causing program interruptions when negative responses are received. In communications with the attached terminals, the 2703 transmits and receives serially-by-bit and serially-by-character. Character buffering of up to four bytes can be accomplished within the unit. When communicating with the channel, the 2703 operates in multiple-byte multiplex mode to request or to transfer a group of up to four bytes each time a line requires service. On both input and output operations with the channel, any message buffering is performed by the processing unit; the 2703 does not impose any restrictions on message length. All necessary bit-byte conversions, data control, and matching to common-carrier equipment are accomplished in the transmission control.

Functional Sections

The 2703 consists of five functional sections: I/O interface controls, common controls and storage, terminal controls, line bases, and line sets (Figure 60).

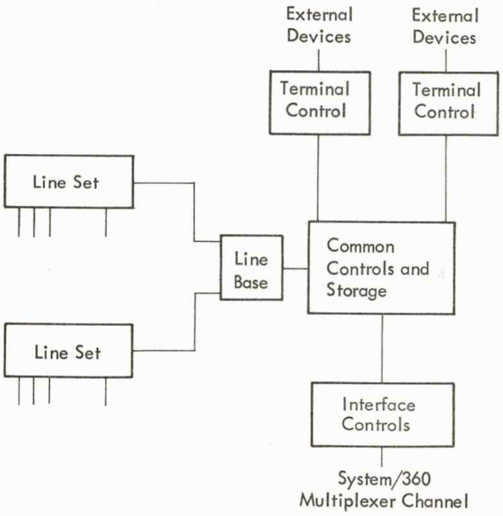


Figure 60. 2703 Functional Sections

I/O Interface Controls Section connects the 2703 to the System/360 multiplexer channel. It recognizes signal sequences from the channel and returns the required sequences in response. Buffering is provided for commands from the multiplexer channel, for data going to or coming from the multiplexer channel, and for addresses from the lines requesting service.

Common Controls and Storage Section accepts commands and data from the multiplexer channel (via the I/O interface controls section) and performs functions common to all communications lines. A magnetic core storage is provided to store control information and to buffer commands and data.

Terminal Control Sections perform functions associated with a particular type of communications equipment. The terminal controls act as an extension of the common controls, performing such unique duties as character-sequence recognition, control-type character decoding, and shift-detection. At least one terminal control is required; as many as five may be chosen. Each terminal control can service all terminals of the same type.

Line Bases Section performs bit sampling. It accepts bits directly from the line adapters in a receive operation and buffers and time-multiplexes the data before sending the bits on to the common controls and storage section. The reverse procedure takes place during a transmit operation.

Line Set Sections interface the communications facilities to the 2703 and provide bit buffering for the transmit data line. At least one line set must be used. Each line set consists of eight line adapters, with each adapter servicing one communications line. The choice of line set is generally independent of the type of terminals but dependent upon the communications facility specified.

Special Features

Automatic Call Feature provides the capability of automatically dialing remote terminals under control of the processor program.

Two Processor Switch Feature allows the 2703 to attach to two Systems/360 multiplexer channels. Operations occur over only one interface at a time.

Line Speed Option Feature makes available as many as seven different line speeds for use with the 2703.

IBM 2712 Remote Multiplexer

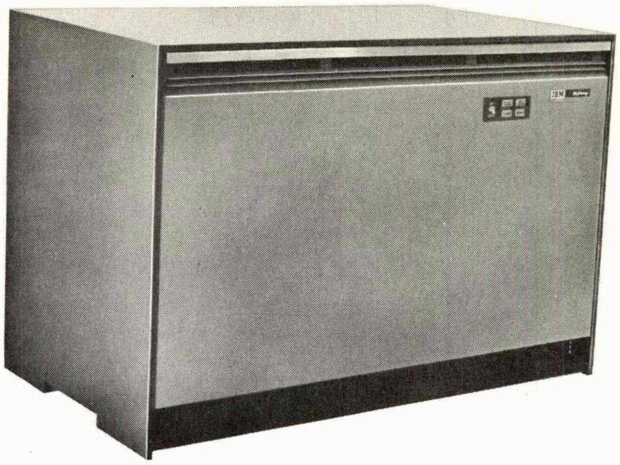


Figure 61. IBM 2712 Remote Multiplexer

The IBM 2712 Remote Multiplexer (Figure 61) minimizes communications costs without reducing throughput or efficiency. It concentrates transmission from several remote terminals over one high-speed line instead of using directly attached multiple low-speed lines. The IBM 2712 allows data transmission to proceed simultaneously in both directions between remote terminals and an IBM System/360 equipped with either the IBM 2702 or 2703 Transmission Control. Figure 62 shows a typical data communications configuration that effectively uses the 2712.

Two models of the 2712 are available. Model 1 operates with IBM 1050, 1060, 2740, and 2741 terminals (134.5 bits per second). Ten point-to-point or multipoint low-speed lines can be attached to a Model 1. Model 2 operates with 74.2 bit per second telegraph terminals over as many as 14 low-speed lines. Terminals that operate at different transmission rates cannot be intermixed in the same 2712 network.

The 2712 operates in the bit-multiplex mode: each of the 10 (or 14) low-speed lines is sequentially scanned, and a single bit of data is removed from each line during a scan cycle. These bits are formed into a word that is transmitted at high speed to the 2702 or 2703. For data transmitted to remote terminals, the 2712 receives a series of words from the 2702 or 2703. It separates each word into bits and places each bit on the low-speed line associated with the receiving terminal.

The 2702 or 2703 is connected to the 2712 Remote Multiplexer through a 2712 Model 1 or Model 2 Adapter. The adapter separates the high-speed line into its respective low-speed lines. The high-speed line is four-wire full-duplex; it can operate processor-to-terminal as well as terminal-to-processor. This ability permits some terminals to be transmitting while other terminals that are using the same 2712 are receiving.

The 2712 and its adapter on the transmission control are transparent to the user. Thus, in a system employing these devices, System/360 is programmed as if the remote terminals were directly connected to the 2702 or 2703 by separate low-speed lines.

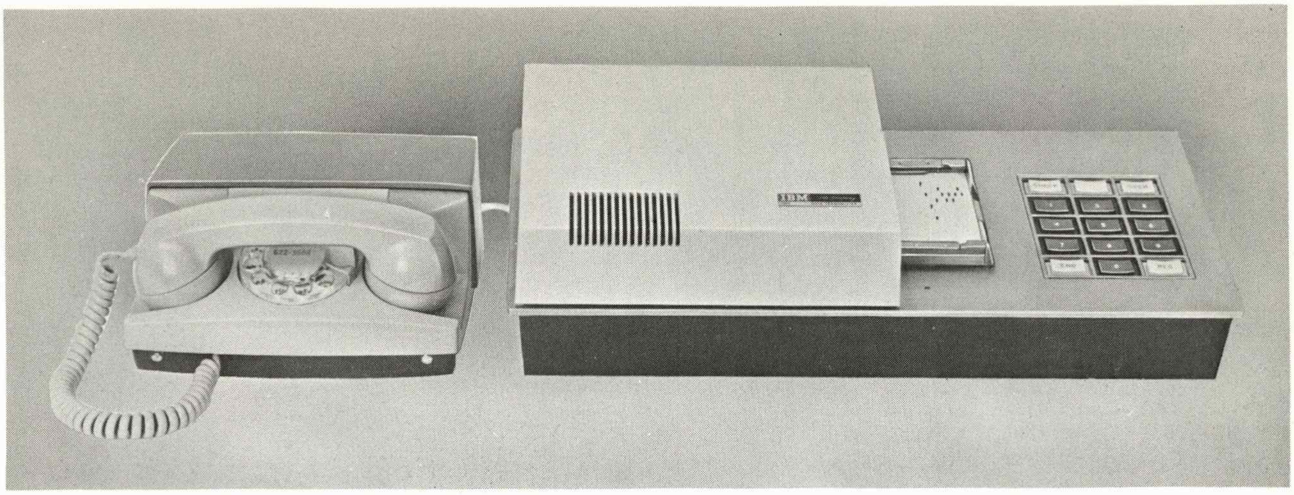


Figure 62. Typical IBM 2712 Configuration

Terminals

IBM 1001 Data Transmission Terminal

The IBM 1001 Data Transmission Terminal (Figure 63) is a combination punched card and keyboard unit used for direct transmission to an IBM 7770 Model 3 or an IBM 7772 Audio Response Unit. The audio response unit is, in turn, connected to System/360 via the multiplexer channel. The 1001 transmits at 12 characters per second over common-carrier leased private line telephone service, common-carrier switched telephone networks, or privately-owned voice-grade facilities. The connection between the 1001 and the audio response unit is established by dialing a telephone.

IBM 1092 and 1093 Programmed Keyboards

The IBM 1092 Programmed Keyboard (Figure 64) and the 1093 Programmed Keyboard (Figure 65) can be connected to System/360 in two different teleprocessing configurations:

1. Over common-carrier communications facilities to either an IBM 7770 Audio Response Unit Model 3 or an IBM 7772 Audio Response Unit.

2. Through a 1051 Control Unit that is connected to a System/360 via communications facilities. When attached to a 1051 Control Unit, these keyboards act as an input unit and occupy a reader position.

These two keyboards can each be used alone, or they can be used in tandem. In a configuration with a

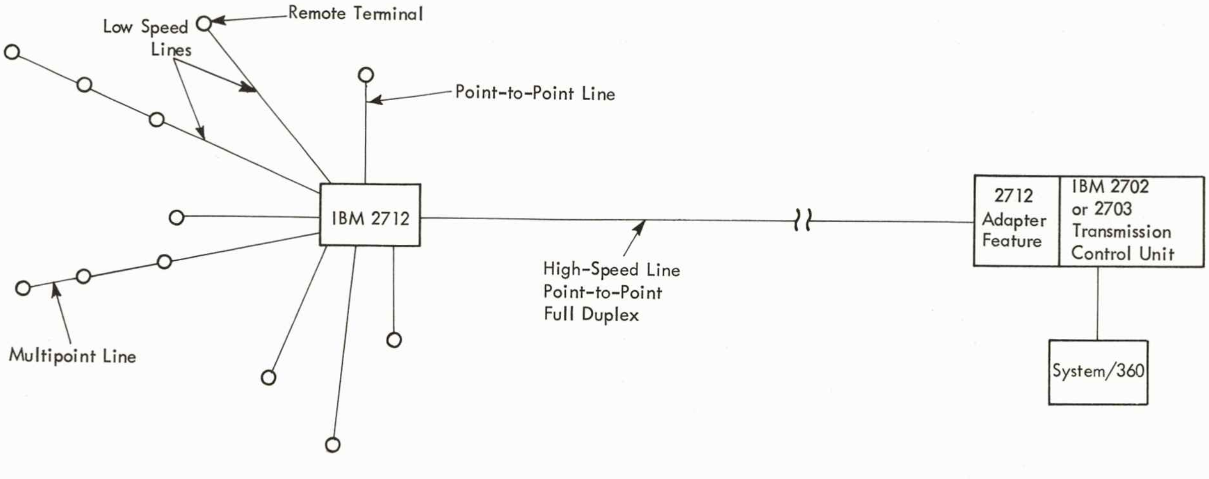


Figure 63. IBM 1001 Data Transmission Terminal

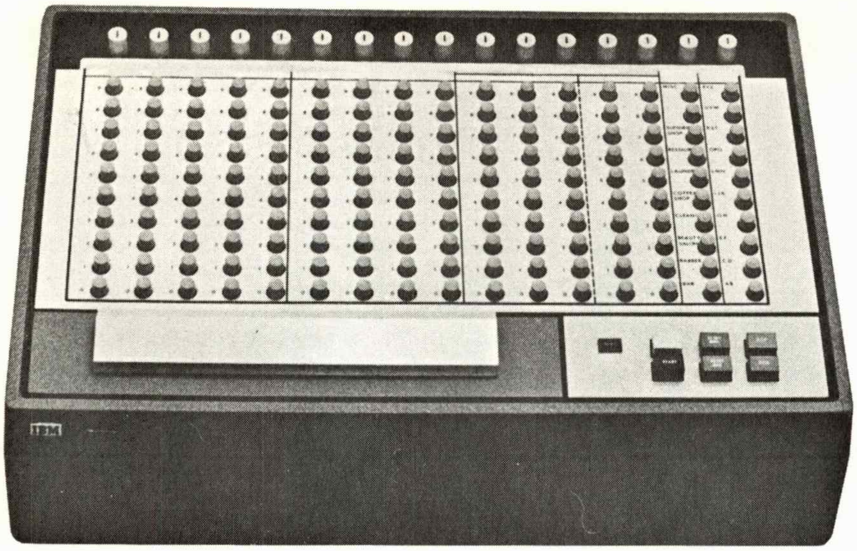


Figure 64. IBM 1092 Programmed Keyboard

1051 Control Unit, up to two 1092's, 1093's, or 1092-1093 tandems can be attached in any combination. Transmission occurs at 14.8 characters per second. When transmitting to an audio response unit, the 1093 may be used alone, but the 1092 must be used in tandem with the 1093. Transmission to an audio response unit occurs at 12 characters per second.

All data entered from these keyboards can be visually checked before they are entered into the system because the data keys pressed (one per column) remain latched until manually restored. Scanning and transmission of the keyed data occur when the terminal is polled, following depression of the start button.

The 1092 and 1093 are designed to accept plastic keymats that are available from IBM. These prepunched but unprinted sheets fit over the data keys and serve as key identification. The user designs the key designations and prints them on the keymats.

Both keyboards are available in two models. The 1092 Model 1 provides 15 columns of data keys and keymat ring supports that can accommodate 10 looseleaf type keymats. The 1093 Model 1 provides 10 columns of data keys and does not have keymat ring supports. Model 2 of both the 1092 and 1093 provides a sensing unit on the keyboard directly below the data keys. This unit senses as many as 48 differently coded keymats, which can each be used individually with these Model 2 keyboards. In addition to having this sensing unit, the 1092 Model 2 provides 16 columns of data keys and does not have keymat ring supports.

IBM 2740 Communications Terminal

The IBM 2740 Communications Terminal (Figure 66) features a Selectric typewriter appropriately modified for use as a general-purpose communications terminal. Thus, the 2740 can function alternately as a typewriter

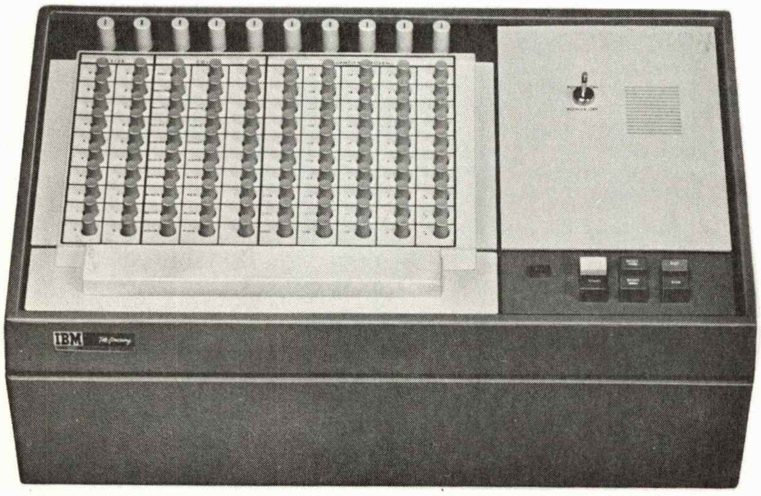


Figure 65. IBM 1093 Programmed Keyboard

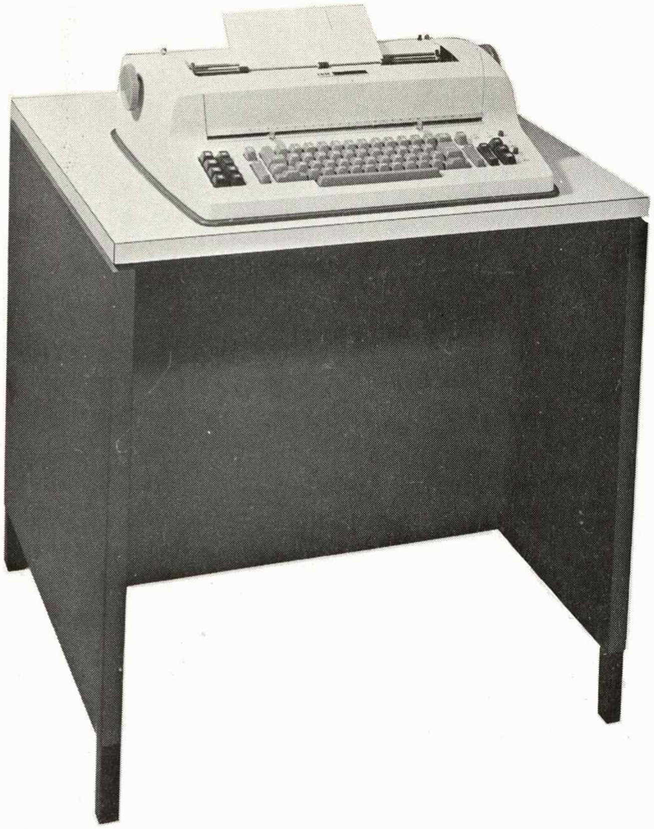


Figure 66. IBM 2740 Communications Terminal

(local mode) or as a data sending and receiving unit (communicate mode). It can communicate either to other 2740 Communications Terminals directly or to System/360 via a 2701 Data Adapter Unit, a 2702 or 2703 Transmission Control, or a 2712 Remote Multiplexer.

When the 2740 is operating in communicate mode, each message character keyed at the sending terminal is printed at both the sending and receiving terminals. Data is transmitted in half-duplex mode over the attached communications lines. The maximum transmission speed is 14.8 characters per second. Effective transmission speed may be less as the operating speed of the 2740 terminal depends on the typing speed of the operator. Some of the many application areas for which the 2740 is designed are:

Intracompany Communication: Internal communication between company departments can be expedited with the 2740.

Remote Inquiry and Reply with a Computer: Using this terminal, individuals having access to a central processing unit can accomplish inquiry and reply type operations without leaving their department area.

Intercompany Correspondence: As a sales aid and to expedite customer orders, a 2740 can be installed in the purchasing department of major customers.

Executive Correspondence: Effective two-way communication is easily maintained between the executive offices and the sales or manufacturing locations by employing the 2740.

The 2740 Communications Terminal can be specified for any one of three types of operation: point-to-point, between two terminals over a private line; dial-up, between two terminals over a switched network; or with a transmission control unit and multiplexer channel. Because the user specifies the particular type of operation he desires when he orders his terminal, he is assured of getting a terminal customized for his particular application.

The 2740 can be operated by any typist with a minimum of additional training. System control keys and indicator lights are conveniently located alongside the typewriter keyboard.

IBM 2741 Communications Terminal

The IBM 2741 Communications Terminal (Figure 67) is a modified Selectric typewriter provided with electronic controls that enable it to operate as a remote conversational terminal, thus permitting direct access to the System/360. When it is not being used for communication, the 2741 may be used for normal office typing. Intended primarily for text-handling and scientific applications, the 2741 Communications Terminal permits persons at remote points to utilize the problem-solving capability of System/360 on a time-sharing basis. (See "Time Sharing.") Among the uses to which this terminal may be put are:

On-line scientific computation
On-line computer programming
Text handling (especially technical writing, proposal writing, and editing)

The 2741, considered by itself, is a typewriter capable of encoding the characters typed and presenting the signal to a communications channel. Therefore, the applications of this terminal are mostly determined by the program used by the System/360 with which it is associated.

The 2741 can communicate over half-duplex circuits with System/360 via a 2701 Data Adapter Unit, a 2702 or 2703 Transmission Control, or a 2712 Remote Multiplexer. Only one 2741 Terminal can be attached to a communications line.

One central processing unit can service many IBM 2741's. The maximum number of terminals that can be used in one configuration depends on either the communications facilities selected or the capacity and equipment of the computer system.

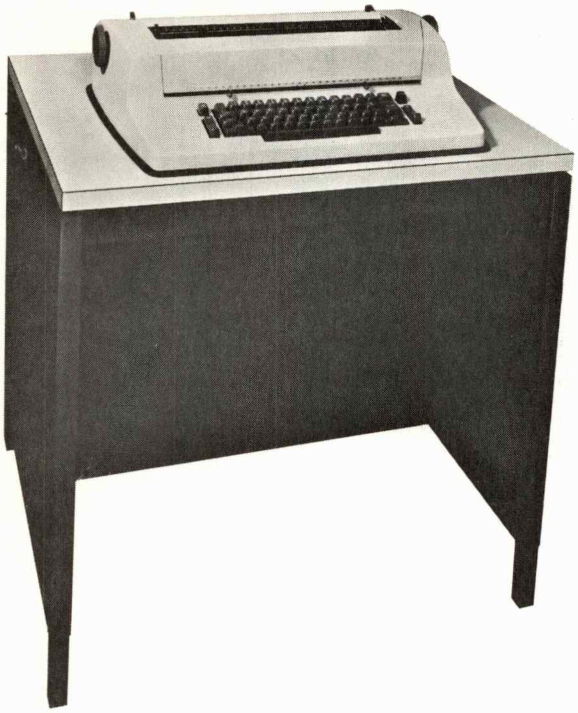


Figure 67. IBM 2741 Communications Terminal

Systems

IBM 1030 Data Collection System

The IBM 1030 Data Collection System (Figure 68) provides a fully integrated on-line data collection system, capable of operating within one plant or between plants. The various components of the 1030 system together form an effective management information system that diminishes the gap between the time when data is originated and the time when it becomes available for use. Some of the applications of the 1030 system include:

Scheduling
Dispatching
Attendance reporting
Inventory maintenance
Labor distribution and performance

The 1030 system collects digital information from diverse reporting stations and transmits it at 60 characters per second to a central System/360 for recording, processing and analyzing.

Connection to the System/360 is effected via either the 2701 Data Adapter Unit or the 2702 or 2703 Transmission Control. Transmission occurs over half-duplex privately-owned communications lines or common-carrier leased private lines.

The specific units that may be combined into a 1030 configuration are:

IBM 1031 Input Station
IBM 1032 Digital Time Unit
IBM 1033 Printer (on-line systems only)
IBM 1034 Card Punch (off-line systems only)
IBM 1035 Badge Reader

IBM 1031 Input Station enables the 1030 system to accept input data in various forms; the system can accept alphameric data from standard 80-column punched cards and numeric data from punched plastic badges, manual entry units, and data cartridges. As many as 24 IBM 1031's can be attached to a 1030 system.

IBM 1032 Digital Time Unit provides time-of-day information for the entire data collection system.

IBM 1033 Printer provides on-line IBM 1030 Data Collection Systems with printed output at locations remote from the central System/360. IBM 1033 printers, in combination with 1031 input stations, offer full on-line inquiry and reply capabilities with the System/360 processing unit.

IBM 1034 Card Punch is the transmission control and output unit for the off-line IBM 1030 System. When the system is designed for off-line use, there is no connection to System/360. Instead, the 1034 Card Punch coordinates transmission from the remote stations and punches standard 80-column cards as output records.

IBM 1035 Badge Reader transmits numeric data at 60 characters per second from 22-column (card-stub size) badges via a 1031 Input Station. As many as four 1035's can be connected to a 1031. Functionally, the 1035 Badge Reader units can be thought of as providing an extension of the badge reading capability of the 1031 unit with which they are associated.

IBM 1050 Data Communication System

The IBM 1050 Data Communication System (Figure 69) is a multipurpose office-oriented teleprocessing system. This versatile system is designed for a wide range of applications in such industries as:

Transportation
Manufacturing
Research
Distribution
Insurance
Refining

In particular, the 1050 system can perform such functions as:

Document Writing of sales order, insurance policies, payrolls, engineering specifications, etc.

Direct Inquiry and Response (real-time operation) with a central processing unit.

Remote Printing of business records and invoices, thus supplying to remote locations full documentation of business transactions.

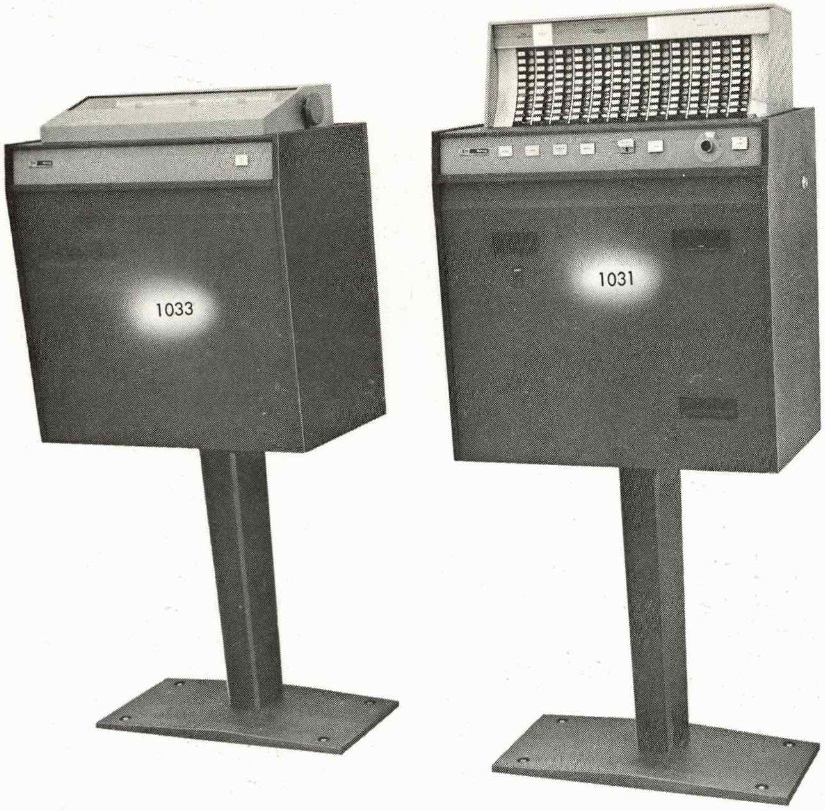


Figure 68. IBM 1030 Data Collection System

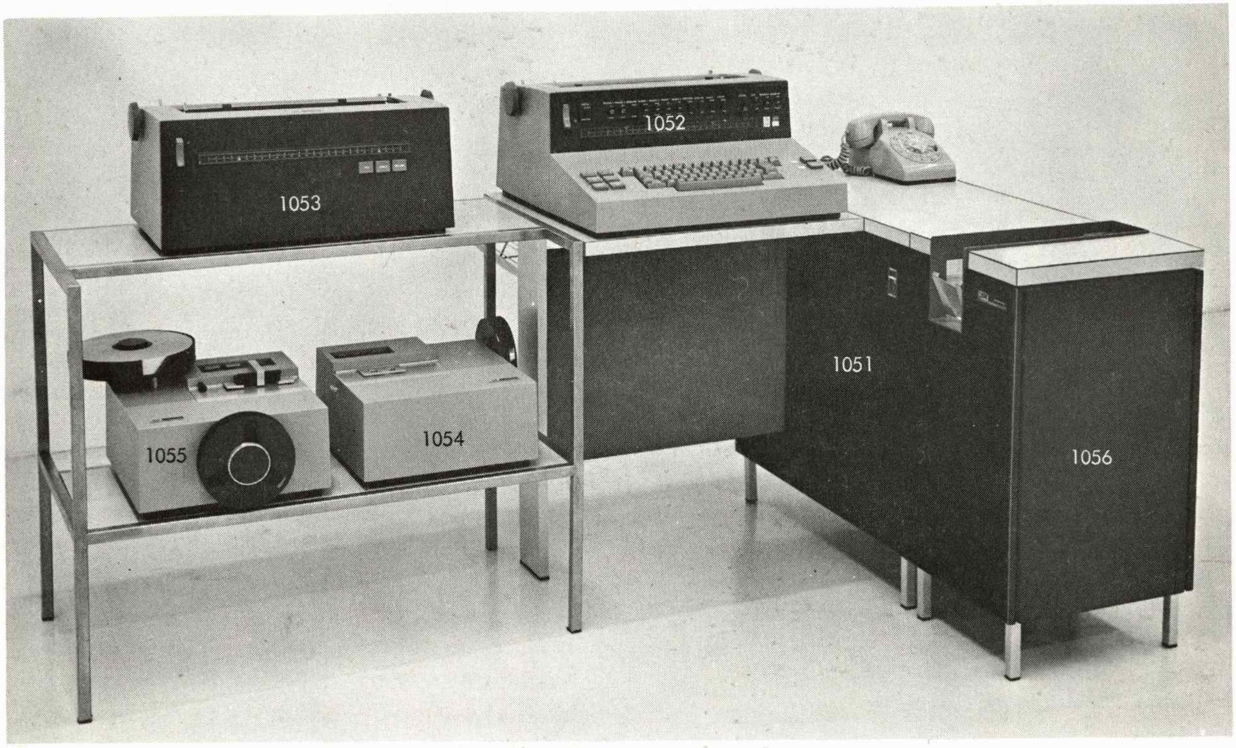


Figure 69. IBM 1050 Data Communication System

Exception Reporting of data about work orders, credit ratings, inventory adjustments, traffic movements, etc.

Intracompany Communication to provide rapid distribution of memorandums, directives, administrative reports, etc.

The 1050 Data Communication System can be connected to System/360 via the 2701 Data Adapter unit, the 2702 or 2703 Transmission Controls, or the 2712 Remote Multiplexer. A special feature allows direct connection of some 1050 system components to a System/360 Model 30. Transmission can occur at 14.8 characters per second in half-duplex mode over leased private, common-carrier switched, or privately owned telephone networks; and either directly between locations, through switching centers, or through message exchanges. The 1050 system is capable of simultaneous home-loop operation (local operation between units of the same 1050 configuration) and line-loop operation (over communications lines to another 1050 system or the System/360).

Data may be entered into the 1050 system by manual keying, by punched cards, by punched paper tapes, and by edge-punched documents. Output from the system may be printed documents, punched cards, punched paper tape, or edge-punched documents.

The versatility of the 1050 system is due in large part to the many configurations it may assume. The minimum configuration contains only an IBM 1051 Control Unit and a receive-only printer; configurations for a wider variety of uses may be designed from combinations of the following available components:

IBM 1051 Control Unit
IBM 1052 Printer-Keyboard
IBM 1053 Printer
IBM 1054 Paper-Tape Reader
IBM 1055 Paper-Tape Punch
IBM 1056 Card Reader
IBM 1057/1058 Card Punch or Printing Card Punch
IBM 1092 and 1093 Programmed Keyboards

The 1051 Control Unit is required in all configurations. It contains the power supply, code translator, data channels, and control circuitry for the 1050 system. All components are electrically connected through the control unit.

For information about the direct connection of 1050 system components to System/360, see the sections on the 1051 Control Unit and the 1052 Printer-Keyboard in the "Manual Controls" section of this manual. For information about the 1092 and 1093 Programmed Keyboards, see the section "IBM 1092 and 1093 Programmed Keyboards."

IBM 1060 Data Communication System

The IBM 1060 Data Communication System (Figure 70) improves services in such institutions as savings banks, savings and loan associations, and commercial banks. It brings the speed and power of the modern computer to the tellers' windows of these institutions, efficiently performing the many accounting functions associated with any particular bank transaction. With this system any teller, at any window, both at the bank's main office and at its widely scattered branch offices, can access all necessary records for any customer. As the daily transactions proceed, the 1060 system provides each customer with an accurate, updated record of his account. The system also provides each teller with this same account information and continuously maintains his balance on hand.

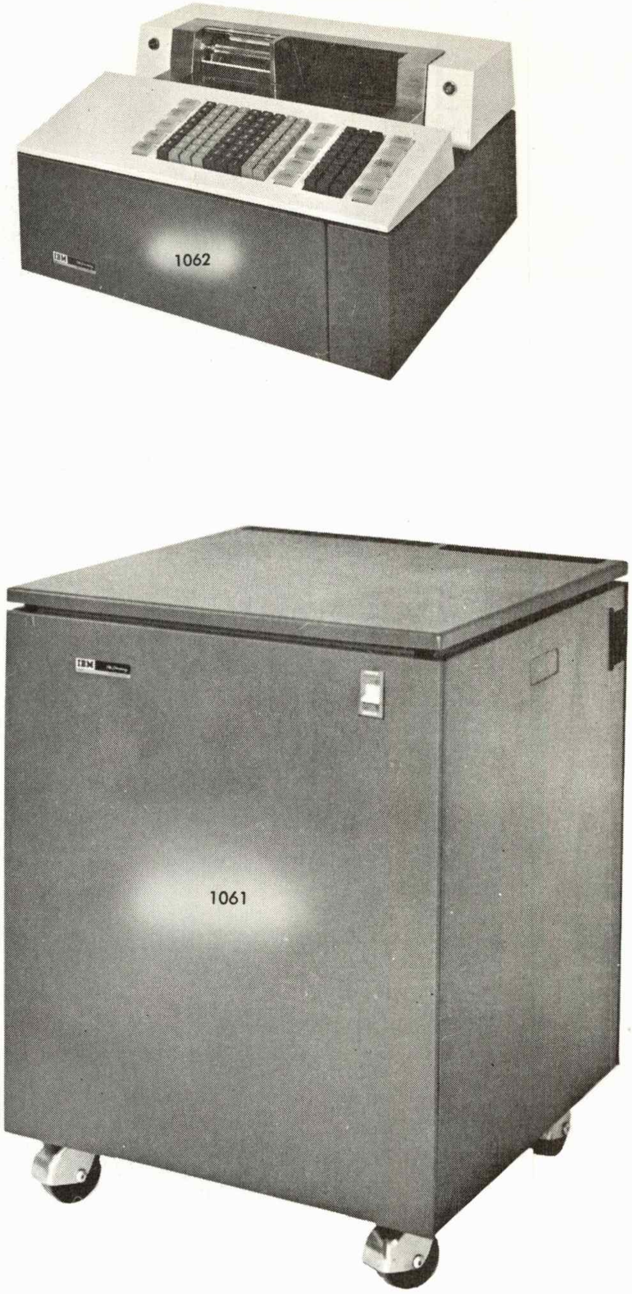


Figure 70. IBM 1060 Data Communication System

Using the IBM 1062 Teller Terminal, a teller can key transaction information from his window to a remotely located System/360. After the System/360 has verified the accuracy of the transmitted information and updated its records, it causes the teller terminal to print out on a customer's passbook any unposted interest, the current transaction amount, and the new balance in his account. The terminal also prints a complete record of both the transmitted and received data on the teller's terminal-record tape. If the system discovers any exception conditions, such as an account tied up in estate or uncollected funds, it immediately informs the teller of these conditions.

The 1060 system, when joined via communication lines with a System/360, forms a complete teleprocessing system. To the System/360, the 1060 appears as an input/output device. Connection of the two systems requires either a 2701 Data Adapter Unit or a 2702 or 2703 Transmission Control. Transmission can occur at 14.8 characters per second in half-duplex mode. An odd parity BCD code is used for transmission.

The IBM 1060 Data Communication System comprises two compact units:

IBM 1061 Control Unit: The IBM 1061 Control Unit is basically the electronic unit of the system. It contains the central logic, code translators, accumulators, data channels and control circuitry for the system and supplies power to the 1062(s). It supplies the line control governing transmission of data to and from a 2701, 2702, or 2703.

A 1061 Model 1 controls one 1062 Teller Terminal Model 1. A 1061 Model 2 controls one 1062 Model 1 and one 1062 Model 2 or, if the off-line feature is installed, two 1062 Model 1's.

IBM 1062 Teller Terminal: The 1062 Teller Terminal is basically the mechanical unit of the system. The 1062 contains a print unit, a terminal-record tape, a document feed, a keyboard, a program tape unit (Model 1 only), and various keys, lights, and switches. Each 1062 terminal can serve two tellers.

Off-Line Operation

Even if communications cannot be maintained between the 1060 system and the System/360, the 1060 can continue to operate by going off-line. When the 1060 is off-line, it is under control of a punched program tape that is a part of the 1062 Teller Terminal (Model 1). The program tape instructs the 1061 Control Unit to perform the arithmetic functions necessary to process transactions and to develop new passbook balances. During off-line operation all customer transactions proceed normally without reference to the System/360. When communications between the two systems are restored, transactions that were handled off-line are entered into the data processing system, which then updates its account records.

Among the features available on the 1060 system is an adding machine feature, which allows the use of the teller terminal as an adding machine; this feature is included if the terminal has the capability of going off-line. A check writing feature permits the insertion of checks into the document feed for amount printing.

Line Adapter Units

IBM 2711 Line Adapter Unit

The IBM 2711 Line Adapter Unit enables the users of the IBM 2702 and 2703 Transmission Controls to package IBM line adapters within one unit. Each 2711 can contain as many as 32 line adapters. The IBM line adapters modulate and demodulate signals over communications facilities in a manner similar to that of the common-carrier data sets that would otherwise be needed to perform these functions. Use of the 2711 Line Adapter Unit with IBM line adapters in lieu of common-carrier data sets offers improved flexibility of system design and economy.

Three types of line adapters can be installed. They provide facilities for:

1. Communication over limited distances (eight miles or fewer).
2. Communication over privately owned or leased common-carrier facilities.
3. Simultaneous sharing of a voice-grade line by as many as four low-speed terminal lines. (Each low-speed line may be operated either point-to-point or multipoint.)

Functional Sections

The 2711 Line Adapter Unit contains two functional sections, the line adapter module and the line adapter.

Line Adapter Module: Each feature provides for the attachment of four line adapters. The basic 2711 can accommodate up to four IBM Line Adapters. If more than four are required, up to seven additional line adapter modules can be added to provide for a total of 32 line adapters per 2711.

Line Adapters: Line adapters enable the matching of 2702 or 2703 signals with those of the communications line. One line adapter is required for each communications line.

Audio Communications

IBM 7770 Audio Response Unit Model 3

The IBM 7770 Audio Response Unit Model 3 (Figure 71), designed for operation with System/360 exclusively, provides a spoken response to digital inquiries

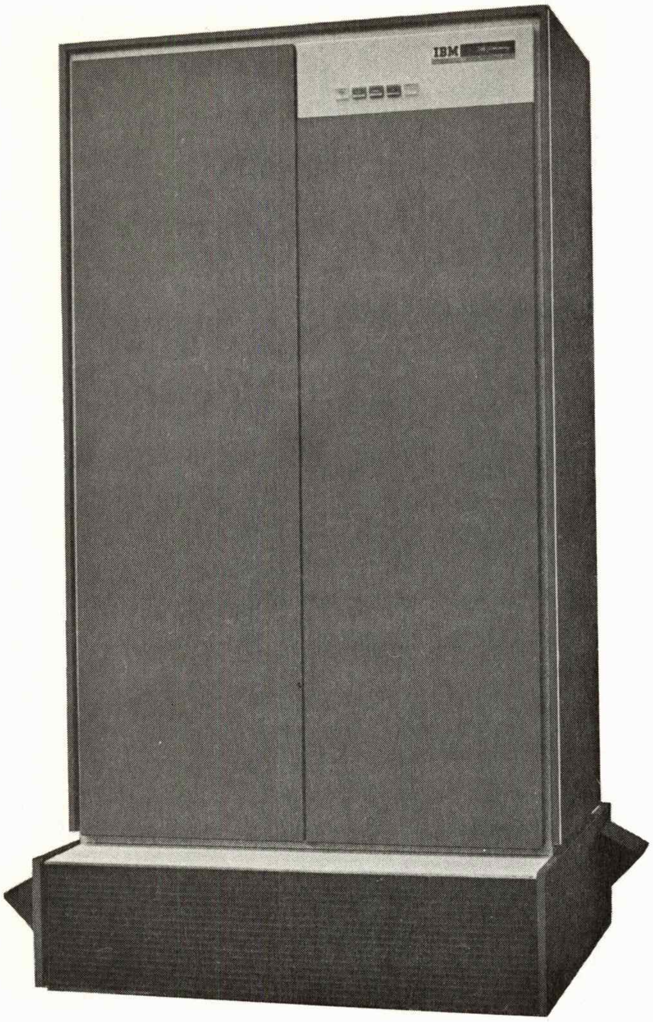


Figure 71. IBM 7770 Audio Response Unit Model 3

from telephones; IBM 1092 (in tandem with the 1093), and IBM 1093 (stand-alone) Keyboards; IBM 1001 Data Transmission Units; or similar terminals. The spoken response is composed from an American English vocabulary prerecorded in a male or female voice on a magnetic drum within the 7770. The response is transmitted over appropriate common-carrier communications facilities back to the inquiring terminal. When the 7770 is operating in conversational mode, the inquiry-response sequence may be repeated any number of times without redialing the 7770.

To make an inquiry of the 7770, the calling party enters a series of characters from his terminal. The 7770 passes these characters one by one via the multiplexer channel to the System/360, which processes the inquiry and sends a response message back, character by character, to the 7770. This response message is a series of drum word addresses that the 7770 uses to select the proper words for its spoken reply. There is no limitation on the length of the inquiry or of the response.

The 7770 Audio Response Unit Model 3 attaches to System/360 via the multiplexer channel. Each 7770 occupies one control unit position and requires one multiplexer subchannel for each communications line. The basic 7770 handles four half-duplex, voice-grade communications lines, but this capacity can be expanded in four-line increments to 48 lines. Random inquiries on all input/output lines can be responded to simultaneously. All data sets must be provided by a common carrier.

Each 7770 comes with a 32-word vocabulary that can be expanded in 16-word increments to a maximum of 128 words. Vocabulary words may be specified by the user according to message requirements. However, lengthy words must be split and will count as two words. The vocabulary can be changed at any time by removing the drum and replacing it with another having a different vocabulary. One word of each user vocabulary must be silence.

Special Features

I/O Line Expander: Each I/O line expander feature provides for four additional input/output lines. A maximum of 11 of these features is allowed.

I/O Line Frame: The I/O line frame feature is needed to provide an additional frame when the number of input/output lines exceeds 16.

I/O Line Panel: An I/O line panel is required for each group of eight input/output lines or portion thereof added beyond the first eight lines. A maximum of five panels is allowed.

Additional Vocabulary Words: Increments of 16 words may be added up to the maximum of 128 words.

End of Inquiry (EOI) Disable: Allows EOI character on push-button telephones to be used as a data character instead of an EOI character.

IBM 7772 Audio Response Unit

Similar to the 7770 Audio Response Unit previously discussed, the IBM 7772 Audio Response Unit (Figure 72) provides a spoken reply in male or female voice to inquiries from the same group of terminals. There are a number of differences between the two units, however.

In the 7770, the audio response comes from a vocabularly pre-recorded in analog form on a magnetic drum within the 7770 itself. In the 7772, the audio response comes from a vocabulary pre-recorded in digitally coded voice and stored in a direct access storage device. Instead of receiving a series of drum addresses from the processing unit, the 7772 receives the digitally coded voice messages, which it converts to audio. Another difference between the two units is that the 7770 offers a limited vocabulary with many I/O communi-

Figure 72. IBM 7772 Audio Response Unit

cations lines (four lines basic, expandable with special features to 48), whereas the 7772 offers unlimited vocabulary with a small number of lines (two lines basic, expandable with special features to a maximum of eight lines.)

The 7772 Audio Response Unit connects the communications facilities to System/360 via the multiplexer channel. The 7772 operates in half-duplex mode over common-carrier switched telephone networks, common-carrier leased private line switched telephone service, and privately owned communications networks of voice-grade. Each audio response unit occupies one control unit position on the channel and requires one subchannel for each of its attached communications lines.

Special Features

End of Inquiry (EOI) Disable: Allows EOI character on push-button telephones to be used as a data character instead of an EOI character.

I/O Line Expander: Each I/O line expander feature provides two additional input/output lines to the 7772. As many as three of these features may be attached.

Additional Vocabulary Words: IBM supplies each user with a complete library of the most frequently used American English words associated with commercial and industrial applications. The entire library is available in digitally coded form on either punched cards or magnetic tape. In addition, a user may request 10 additional discrete American English words without charge. When he chooses the additional vocabulary words feature, he can add as many more words to his library as he needs for a small cost.

Data Acquisition and Process Control

A high-speed data acquisition system is designed to maintain constant communication with a process for such purposes as:

1. Determining whether the process is operating within acceptable limits.
2. Providing records for accounting or management decisions.
3. Providing a record of data obtained during a research experiment.

A process control system usually incorporates data acquisition facilities and has the additional capability of using the acquired data as a basis for supervising and controlling the process.

There are three basic System/360 configurations designed to satisfy the requirements for real-time data acquisitions, analysis, and process control:

1. IBM 1070 Process Communication System.
2. IBM 1800 Data Acquisition and Control System.
3. IBM 1827 Data Control Unit with IBM 1800 Data Acquisition and Control System process input/output devices and features.

Each of these three basic configurations can accept both analog and digital electrical signals from such devices as thermocouples, pressure transducers, flow meters, analytical instruments, and contacts. They can also provide both analog and digital electrical signals to actuators, analog controllers, annunciators, lights, and contacts.

IBM 1070 Process Communication System

The IBM 1070 Process Communication System (Figure 73) is a data acquisition and control system designed for two-way data communication over standard communications lines between remote process locations and a central data processing system. The 1070 system has the necessary ruggedness and compactness to allow its use in a wide variety of industrial environments. The 1070, for example, can collect and transmit data from refineries, chemical plants, paper mills, steel mills, and manufacturing areas. The 1070 equipment at each process area can be either operator-oriented or fully automatic. Except for the 1053 printer, all 1070 units can be mounted in a standard 19-inch rack.

When the 1070 is connected to System/360, the two systems form a complete management information system. With this system, management can supervise quality and production, schedule jobs to take advantage of available equipment or to meet emergency needs, and perform on-line accounting. The 1070 system connects to System/360 through the 2701 Data Adapter Unit or the 2702 or 2703 Transmission Controls. As many as twenty-six 1070 terminals may be attached to one communications line. The 1070 transmits and receives in half-duplex mode over voice- or subvoice-grade lines at 14.8 or 66.6 binary-coded-decimal characters per second (corresponding to bit rates of 134.5 or 600 bits per second), depending on which model of the IBM 1071 Terminal Control is chosen. When operating at 134.5 bits per second, 1070 and 1050 systems may be mixed on the same communications line. Transmission at this rate may take place over leased common-carrier telephones lines, Western Union leased subvoice-grade service, or privately-owned communications lines. Transmission at 600 bits per second may take place over leased common-carrier or privately-owned communications facilities. All data transmitted and received are checked for validity.

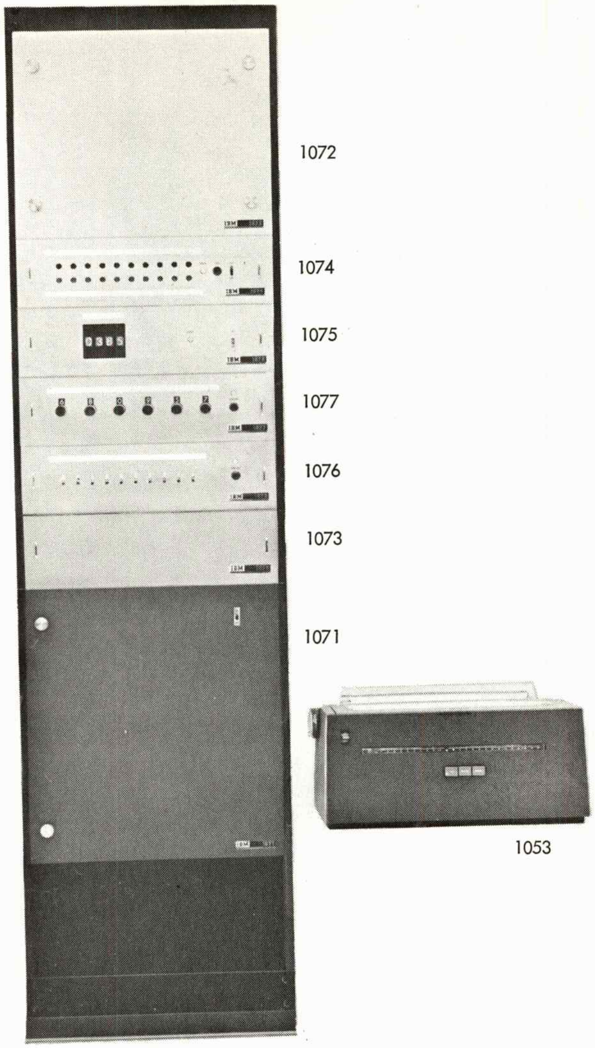


Figure 73. IBM 1070 Process Communication System

The 1070 system consists of the following units:

IBM 1071 Terminal Control (one required in each system)
IBM 1072 Terminal Multiplexer (one required in each system; up to six can be installed)
IBM 1073 Terminal Units

Process Operator Console Units
- IBM 1074 Binary Display
- IBM 1075 Decimal Display
- IBM 1076 Manual Binary Input
- IBM 1077 Manual Decimal Input
- IBM 1078 Pulse Counter
- IBM 1053 Printer

IBM 1071 Terminal Control: This unit is the control center of the 1070 terminal. All data to and from the System/360 are channeled through it. The basic 1071 contains logic for addressing 50 input/output points. This capacity can be expanded to 300 points, in modules of 50. (A point is a termination for a pair of wires.) The 1071 provides contact sense, decimal, and BCD input; in addition it performs contact operate functions, analog-to-digital conversion (via set-point stations) and controls all operator communication units.

IBM 1072 Terminal Multiplexer: This unit can provide terminal posts and switching relays for 50 process signals.

IBM 1073 Terminal Units: These units sense and control the opening and closing of switches that operate user devices.

Process Operator Console Units: These units allow the operator at the process location to enter binary and decimal data, and to receive a binary or decimal display or a printed output.

IBM 1800 Data Acquisition and Control System

The IBM 1800 Data Acquisition and Control System (Figure 74) is a versatile, high-performance system designed to handle a wide variety of real-time applications, especially process control and high-speed data acquisition. Unlike conventional data processing equipment, the 1800 system is designed primarily to monitor and record a wide variety of data as it is generated in a plant or laboratory. Using the collected data as a basis, it can create the signals to control a user's process or recording equipment. In addition, the 1800 system can be linked to the System/360 (Models 30, 40, 44, or 50) either to increase the total system computing power, or to form a management information system in which production-line data is used to update inventory records, perform cost accounting, or handle other general business data processing jobs.

Among the continuous process control applications for which the 1800 system is suited are petroleum refining, chemical processing, steel rolling, pipeline monitoring, and power generation. The high-speed data acquisition facilities of the 1800 system are especially useful in missile pre-launch and manufacturing checkout, nuclear reactor analysis, medical-clinical analysis and monitoring, medical research, and many other applications.

The 1800 Data Acquisition and Control System allows the connection of both real-time process I/O features—such as analog input, analog output, contact sense, and contact operate—and data processing I/O devices. Because the various 1800 system units are modular, both large and small system users can design systems to suit their needs. Among the units that a user can choose to make up his 1800 system are:

- IBM 1801/1802 Processor-Controller
- IBM 1816 Printer-Keyboard
- IBM 1826 Data Adapter Unit
- IBM 1827 Data Control Unit (This is actually a System/360 I/O control unit. See description that follows.)
- IBM 1828 Enclosure
- IBM 2310 Disk Storage
- Printers
- Card Read Punches
- Paper Tape Readers and Punches
- Magnetic Tape Units

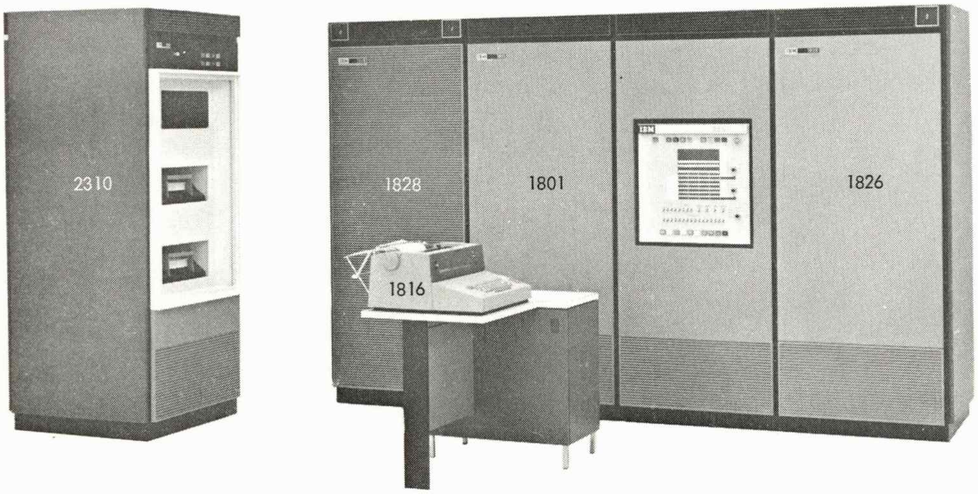


Figure 74. IBM 1800 Data Acquisition and Control System

1801/1802 Processor-Controller

The 1800 system is available with two processor-controllers: the 1801 and the 1802. Each processor-controller is available in two models: the Model 1 has a main storage cycle of 4 microseconds; the Model 2 main storage cycle is 2 microseconds. Both models are available with four main storage capacities, ranging from 4,096 to 32,768 sixteen-bit words. (See the table below.) In addition, the 1802 (both models) includes circuitry and control for connection and operation of the IBM 2401 and 2402 Magnetic Tape Units.

Each processor-controller provides three data channels (operating at speeds up to 500,000 words per second in burst mode with the 2-microsecond main storage), three index registers, three interval timers, a powerful instruction set, indirect addressing, twelve levels of interrupt, and a storage protection feature. As many as six more data channels and 12 additional levels of interrupt may be added as special features.

1801/1802 MODEL 1 (4-USEC STORAGE CYCLE)	1801/1802 MODEL 2 (2-USEC STORAGE CYCLE)	MAIN STORAGE (WORDS)
1A	2A	4,096
1B	2B	8,192
1C	2C	16,384
1D	2D	32,768

Connection to System/360

Major components of the 1800 system can be connected to System/360 in two ways. A complete 1800 system, with processor-controller, can be connected to System/360 via the System/360 Adapter feature. When no processor-controller is involved, the 1800 system process I/O devices can be directly connected to a System/360 channel via the 1827 Data Control Unit.

System/360 Adapter: The System/360 Adapter, functionally equivalent to the channel-to-channel adapter discussed earlier in this manual, permits the attachment of the 1800 system to a channel of the System/360 (Models 30, 40, 44, or 50) via the standard interface. It provides half-duplex communication at rates up to 250,000 bytes per second in the burst mode. Each system regards the other as an I/O device capable of requesting service on a random basis. The adapter connects to either a multiplexer or selector channel of System/360, occupying one control unit position. It requires one data channel on the 1800 system.

1827 Data Control Unit: The 1827 Data Control Unit provides for the attachment of 1800 system analog and digital input, limit comparing, and analog and digital output features to a System/360 (Models 30, 40, 44, or 50) in the absence of an 1801/1802 Processor-Controller. With the 1827 Data Control Unit the capabilities of System/360 are extended to handle a broad range of control applications from high-speed data acquisition to supervisory control of industrial processes.

The 1827 provides the standard interface that permits its attachment to any channel on System/360 Models 30-50. When concurrent operation of 1800 system devices is desired, however, the 1827 is attached to a multiplexer channel or high-speed multiplexer channel; it can then communicate via as many as five subchannels. As many as 288 digital input or output points may be terminated in the 1827. In addition, the 1827 is capable of housing three basic features to interface various devices of the 1800 system: analog input basic, digital input basic, and digital and analog output basic.

1826 Data Adapter Unit: The 1826 Data Adapter Unit provides for the expansion of digital input and output requirements beyond the housing and point capabilities of the 1827 Data Control Unit. One or more 1826's are required whenever the digital process termination points exceed 288 or whenever the combined total of digital input adapters, pulse counter adapters, and digital output adapters exceeds three. (These limitations are imposed by the 1827.) Each 1826 can house 576 process termination points or a combined total of six digital input, digital output, and pulse counter adapters. As many 1826's can be used in a system as are needed to meet a user's requirements, within the limits of the system. The system maximum for digital input is 1,024 points (or pulse counter bit positions) or eight digital input and/or pulse counter adapters. The system maximum for digital output is 2,048 points or 32 digital output adapters.

1828 Enclosure: The 1828 Enclosure provides a 19-inch wide rack for mounting analog input multiplexer terminals and analog output terminals.

Publications

IBM has prepared a number of publications about the 1800 system which should be helpful to the System/360 user. Among those publications most highly recommended are:

IBM 1800 Data Acquisition and Control System Functional Characteristics, Form A26-5918

IBM 1800 Data Acquistion and Control System Summary, Form A26-5920

IBM 1827 Data Control Unit with System/360—Summary Description, Form A22-6868.

IBM®

International Business Machines Corporation
Data Processing Division
112 East Post Road, White Plains, N.Y. 10601
[USA Only]

IBM World Trade Corporation
821 United Nations Plaza, New York, New York 10017
[International]

READER'S COMMENT FORM

IBM System/360 System Summary A22-6810-8

- Your comments, accompanied by answers to the following questions, help us produce better publications for your use. If your answer to a question is "No" or requires qualification, please explain in the space provided below. Comments and suggestions become the property of IBM.

	Yes	No
• Does this publication meet your needs?	☐	☐
• Did you find the material:		
Easy to read and understand?	☐	☐
Organized for convenient use?	☐	☐
Complete?	☐	☐
Well illustrated?	☐	☐
Written for your technical level?	☐	☐

- What is your occupation? ____________________
- How do you use this publication?

As an introduction to the subject?	☐	As an instructor in a class?	☐
For advanced knowledge of the subject?	☐	As a student in a class?	☐
For information about operating procedures?	☐	As a reference manual?	☐

Other ____________________

- Please give specific page and line references with your comments when appropriate. If you wish a reply, be sure to include your name and address.

COMMENTS:

- Thank you for your cooperation. No postage necessary if mailed in the U.S.A.

fold

fold

FIRST CLASS
PERMIT NO. 419
POUGHKEEPSIE, N.Y.

BUSINESS REPLY MAIL

NO POSTAGE NECESSARY IF MAILED IN THE UNITED STATES

POSTAGE WILL BE PAID BY . . .

IBM CORPORATION
P.O. BOX 390
POUGHKEEPSIE, N.Y. 12602

ATTENTION: CUSTOMER MANUALS , DEPT. B98

fold

fold

IBM®

International Business Machines Corporation
Data Processing Division
112 East Post Road, White Plains, N.Y. 10601
[USA Only]

IBM World Trade Corporation
821 United Nations Plaza, New York, New York 10017
[International]